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ENVIRONMENTAL IMPACT REPORT

PEABODY COAL COMPANY

BIG SKY MINE

OCTOBER 15, 1973

APPENDIX

Unless otherwise noted through references
to appendiced material, the authors of this
report are Peabody Coal Company
and
Ecological Consulting Service

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8. Archaeological Reconnaissance by University of Montana Foundation
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10. Noise Survey of Big Sky Mine, Rosebud County, Montana, by Peabody Coal Company

APPENDIX #1

LIST OF PUBLICATIONS ON TRACE ELEMENTS IN COAL

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APPENDIX 1

LIST OF PUBLICATIONS ON TRACE ELEMENTS IN COAL

Bureau of Mines Report of Investigations #7609/1972
"An Evaluation of Methods for Detecting Mercury in Some U. S. Coals"

Bureau of Mines Technical Progress Report #43, September, 1971
"Analysis for Mercury in Coal"

Bureau of Mines Technical Progress Report #54, May, 1972
"Fate of Trace Mercury in the Combustion of Coal"

Illinois State Geological Survey - Environmental Geology Notes #43, February, 1971
"Mercury Content of Illinois Coals"

Bureau of Mines Report of Investigations #7281, July, 1969
"Spectrochemical Analyses of Coal Ash for Trace Elements"

Bureau of Mines Report of Investigations #7054, December, 1967
"Method for Determination of Fluorine in Coal"

Bureau of Mines Information Circular #8163 - Published 1963
"Rare Elements in Coal"

Bureau of Mines Report of Investigations #7714/1973
"Analysis of Trace Elements in Coal by Spark-Source Mass Spectrometry"

Illinois State Geological Survey - Environmental Geology Notes #61, April 1973
"Occurrence and Distribution of Potentially Volatile Trace Elements in Coal: An Interim Report"

The Pennsylvania State University Contract No. 14-01-0001-390, "Mineral Matter and Trace Elements in U.S. Coals". Prepared for Office of Coal Research, U.S. Department of Interior, Research and Development Report No. 61, Interim Report No. 2

APPENDIX #2

OVERBURDEN ANALYSIS

Overburden Analysis
Big Sky Mine, Colstrip, Montana

Introduction

Since 1967, intensive surface mined land reclamation research conducted by the Montana Agriculture Experiment Station has resulted in improved techniques and innovations for practical land reclamation. It has become obvious that mining and reclamation must be a system of coordinated processes used to achieve a predetermined goal in both mineral extraction and land restoration. Careful preplanning will allow mining and reclamation to coexist both economically and ecologically.

Analyses of overburden samples from the potential mine site provide pertinent information on overburden toxicity, stratigraphic ratios, weathering rates, water infiltration and percolation rates, water holding capacity, influences on seed germination and plant growth, nutrient availability, and potential for reclamation.

Reclamation problems differ from mine site to mine site and vary with the types and quantities of overburden removed, local environment, topography, water availability, types of mining equipment used, number of coal seams mined, and overall reclamation objectives.

Samples of overburden were obtained from cores taken from between the outcrop locations of the Rosebud and McKay seams at a proposed minesite location. These samples were submitted for analyses by the Montana Agricultural Experiment Station at Bozeman. The following investigations concern overburden representing the parting shales at Peabody's Big Sky Mine.

Objectives

The objectives of the overburden analysis phase of this research program were to:

1. Determine numerous physical and chemical characteristics of overburden material found between the McKay and Rosebud croplines at Peabody's Big Sky Mine.
2. Determine plant germination and growth characteristics of overburden.
3. Predict problems in revegetation of potential mine spoils at the Big Sky Mine.

Methods and Procedures

Overburden samples were obtained from six holes in the area between the McKay and Rosebud croplines at Peabody's Big Sky Mine. Samples were analyzed as received, and varied from one foot to ten foot increments. Each sample was identified by location, depth and code letters.

Sample Preparation

A special crushing machine capable to regulating maximum particle size was used to crush each sample to a maximum particle diameter of 25 mm.

Standard Soil Analysis

Each soil sample was analyzed by the Montana State University Soil Testing Laboratory to determine pH, phosphorus, potassium, calcium, magnesium, sodium, salts conductivity, and particle size distribution.

Permeability Tests

Special laboratory apparatus were used to test the permeability of artificial soil composed of 50g of 1.0 - 5.0 mm particles and 50g of less than 1.0 mm particles of each overburden sample. A 50 mm diameter glass tube 15 cm long was partially filled with 100g of prepared overburden material and supported by a fine-mesh wire screen on one end of the tube. With the tube in a vertical position, 100 ml of distilled water was slowly dripped into the tube. Water percolated through the sample into a container below, and was measured volumetrically after 10, 30, 60 and 120 minutes and after 24 hours. A flow rate curve was constructed for each sample.

Leachate from each sample was analyzed by the Montana State University Soil Testing Laboratory for pH, calcium, magnesium, potassium, sodium, salts, electrical conductivity, and sodium adsorption ratio.

Plant Growth Tests

Plant growth tests were conducted on overburden samples in the greenhouse. Each overburden sample was composed of a mixture of 50 percent 1.0 - 5.0 mm particles and 50 percent less than 1.0 mm particles. Four 75g replications of each sample were placed in plastic pots, seeded with three barley and one bean seed, and randomized on a greenhouse bench. Plants were watered daily or as required with distilled water. Germination was recorded daily through the designated test period. Plant growth was measured (the average of the tallest three leaves) and plant vigor and color were recorded. After the 45-day test period, plants were harvested, oven-dried, and weighed to supply data for detailed analysis which followed.

Results

The samples received were quite variable in depth increments, but provided a good analysis of the overburden material between the Rosebud and McKay croplines.

A short discussion of the factors and characteristics evaluated during the study is necessary at this time. Rates of permeability are shown in graphs and saturation time is shown in the tables. Both indicate the ability of the sample to absorb water and to allow its movement through the sample. Samples with very low flow rates or which are impermeable would cause severe erosion and revegetation problems if left on the surface of mine spoils.

Soil samples were analyzed for a variety of chemical and physical characteristics including pH, ~~p~~phosphorus, potassium, sodium, calcium, magnesium, salts conductivity, and particle size distribution. Nutrient analysis allows requirements for fertilizer to be formulated. Sodium content generally indicates potential salinity problems. Potential problems are indicated when sodium content exceeds 2-3 milliequivalants/ 100g and salts conductivity exceeds 3-4 millimhos. Particle size distribution indicates the relative proportions of sand, silt, and clay in the sample. When clay exceeds 40-50 percent or when silt and clay exceed 70-80 percent of the sample, problems are encountered in infiltration of water, soil erosion, soil compaction, and plant growth. Soils high in sand hold low amounts of available water while those high in silt and clay hold higher amounts of available water. As noted earlier, soils too high in silt and clay present other reclamation problems.

Leachate samples provide information on waters which percolate through test samples and indicate potential influences on surface and

ground waters which come in contact with particular overburden in spoils. Electrical conductivity is presented in the tables in micromhos while salts content is estimated in parts per million. Salts hazard appears to increase as both electrical conductivity and salts content exceed 2000 micromhos or ppm. Sodium is expressed in milliequivalents per liter, as are calcium, magnesium, potassium, and total salts. Sodium hazard appears to increase above 2-3 meq/l. Sodium adsorption ratio (SAR) indicates the ratio of sodium to calcium and magnesium and is used to predict plant growth problems. Soils having SAR values greater than 10-12 are considered alkaline and are limiting to plant growth and establishment. High sodium decreases plant growth by affecting plant nutrition, water use, and soil physical properties (Appendix A).

Germination is shown as the percent of seeds planted which germinated. Leaf length expresses the average total leaf length per pot of the three tallest leaves measured midway through the plant growth tests. Productivity indicates average weight per pot at the end of the tests. The leaf length for the control soils averaged 683 mm and production averaged 1.045 g/pot.

The following pages discuss each drill hole separately in predicting reclamation problems.

Drill Hole B-1

Drill hole B-1 contained a brown sand for 31 feet, 3 feet of Rosebud smut, 5 feet of gray sand, 13 feet of gray shale, and then McKay coal.

The brown sand did not inhibit infiltration of water (Figure 1), and had good textural qualities with an average of 64% sand, 20% silt, and 16% clay (Table 1). Salts and sodium were only moderately high in a few of the materials sampled, but were quite high in some of the leachate samples, especially from those around 15 feet. SAR values were not high even with the high sodium concentration because they were accompanied by a high calcium and magnesium content. Percent germination was high for all samples (Table 2), and plant growth was excellent to fair. Phosphorus would be a limiting plant nutrient in much of the brown sand portion of this overburden. This material appears to be a good plant growth medium unless subjected to large quantities of water, in which there could be possible salt contamination of ground water.

The Rosebud smut portion of this overburden ranges from very permeable to very impermeable, and is also very inconsistent in other characteristics tested. This material should not be left on or near the surface of mine spoils.

The gray sand from this drill hole does not appear to be problematical for reclamation purposes, except that it is possibly too coarse to have a satisfactory soil moisture capacity, and maybe low in phosphorous (Table 1).

The gray shale would not be a good plant growth medium because of its impermeability caused by excessively high silt content. Under greenhouse conditions plant production was good, but watering is done in a manner that tends to obscure the detrimental effects of impervious soils.

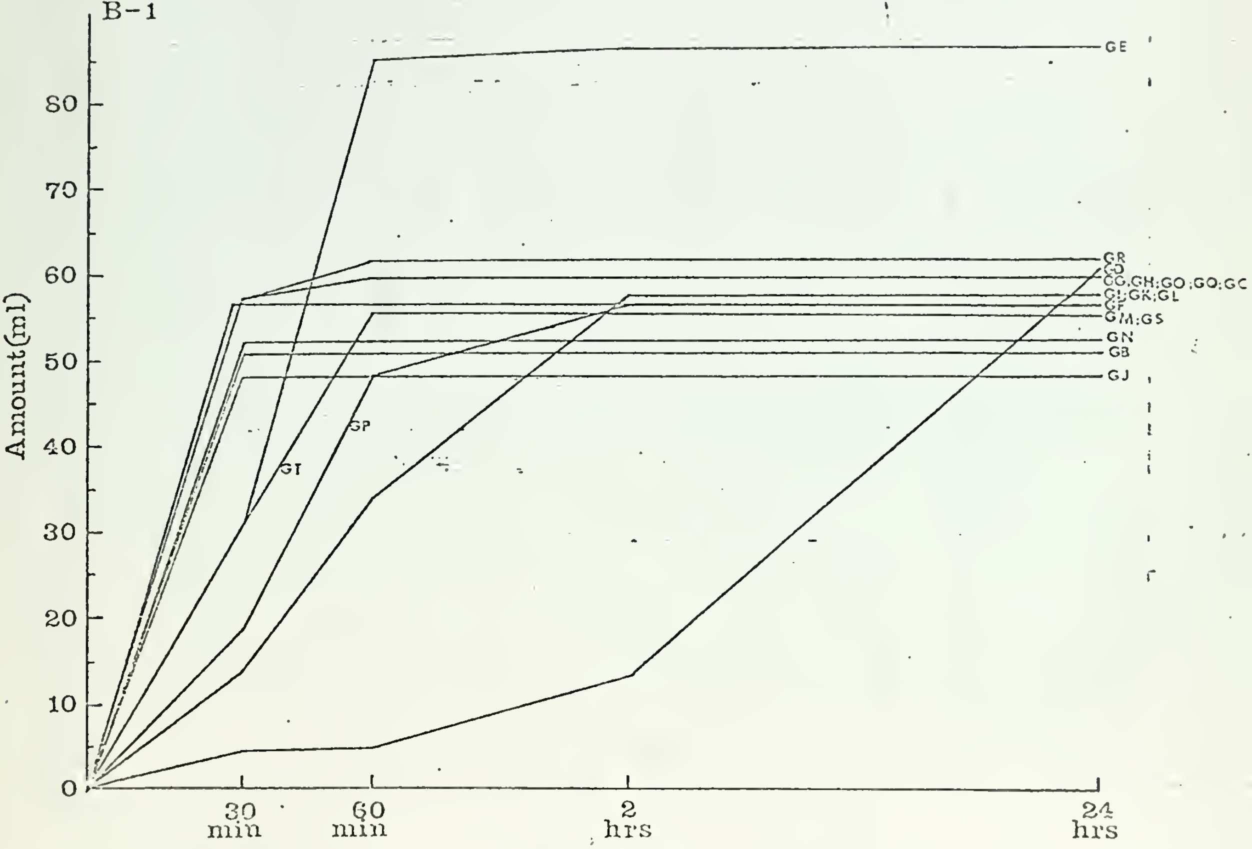

Figure 1. Rate of water flow through permeability test apparatus for samples from Line B hole No. 1.

characteristics of (line B) hole No. 1 overburden.

Depth (ft)	Leachate						Soil								Code
	pH	E.C.	Salts	Na	Total	SAR	pH	P	K	Na	Salts	Sand	Silt	Clay	
1-2	7.3	360	229	.82	2.79	.70	8.6	10	85	.51	.6	43	23	34	GB
2-4	8.1	380	241	.68	2.76	.59	9.0	3	45	.48	.5	65	16	19	GG
4-6	8.4	1000	642	12.39	2.94	10.66	9.3	5	75	1.00	2.9	63	20	17	GI
6-8	8.5	1500	965	15.22	56.56	2.86	9.0	1	95	1.24	1.5	61	18	21	GL
8-10	7.9	2500	1615	16.74	19.08	5.48	8.6	5	75	1.24	.9	69	14	17	GQ
10-12	7.0	3100	2000	10.87	32.04	2.72	8.5	3	25	1.03	3.3	73	13	14	GC
14-16	7.7	8600	5610	32.17	123.55	4.09	8.5	13	65	2.24	1.1	48	46	6	GJ
16-18	7.7	6900	4495	25.87	83.05	4.01	8.5	10	45	1.63	6.1	63	26	10	GM
18-20	7.7	3900	2515	16.74	43.51	3.59	8.4	1	25	1.11	3.2	81	5	14	GR
22-24	8.0	2700	1750	13.48	28.77	3.56	8.6	1	15	1.27	.7	67	28	5	GH
26-28	7.9	2100	1350	3.33	22.28	1.00	8.5	3	15	.87	1.6	72	12	16	GN
30-31	7.5	1500	965	3.01	12.15	1.18	8.5	1	45	.80	1.5	41	34	25	GD
31-32	7.9	180	113	.43	.75	.73	8.0	8	25	1.00	2.5	79	10	11	GE
34-36	7.8	2500	1615	12.39	27.45	3.35	8.5	1	25	1.00	2.2	75	12	13	GO
38-40	7.8	1100	700	1.37	8.28	.68	8.4	18	15	.59	1.0	63	24	13	GS
40-42	7.9	1600	1035	9.13	13.89	3.54	8.5	5	85	.64	1.2	27	30	43	GF
44-46	8.4	1200	771	2.26	7.63	1.06	8.5	1	35	.64	.9	26	54	20	GK
46-48	8.2	1400	900	2.85	10.60	1.28	8.7	8	65	.67	1.5	31	48	21	GP
48-50	8.3	1300	838	2.72	9.52	1.28	8.3	10	115	.85	1.0	21	32	47	[illegible]

Physical characteristics and production of Line 5 Hole No. 1 overburden.

Depth (ft)	Sat. Time (min:sec)	% Moisture at F.C.	Germination (%)	(mm) Leaf Length	Productivity (g/pot)	Code
1-2	13:14	35.4	92	584	.853	GB
2-4	11:05	28.2	100	398	.670	GG
4-6	12:25	28.3	100	398	.730	GI
6-8	11:25	27.3	92	401	.833	GL
8-10	13:05	31.6	-	-	-	GQ
10-12	11:15	24.8	100	493	.723	GC
14-16	13:55	35.3	100	694	.493	GJ
16-18	12:00	27.5	100	557	.723	GM
18-20	12:20	28.9	92	414	.540	GR
22-24	11:50	26.2	100	474	.658	GH
26-28	13:30	31.4	100	499	.635	GN
30-31	46:00	24.2	-	-	-	GD
31-32	3:00	1.3	-	-	-	GE
34-36	12:55	32.5	100	516	.683	GO
38-40	13:05	33.0	100	535	.648	GS
40-42	13:25	27.5	92	645	.798	GF
44-46	14:30	29.4	92	396	.828	GK
46-48	16:46	34.0	92	457	.840	GP
48-50	14:40	35.2	92	524	.835	GT

Drill Hole B-2

Drill hole B-2 contained a brown sand for the first 25 feet, Rosebud smut for 2 feet, gray shale for 4 feet, then McKay coal.

The brown sand section of this drill hole is quite permeable (Figure 2) and has good textural qualities with an average of 68% sand, 16% silt, and 16% clay (Table 3). The leachate of this sample is moderately high in salts and sodium. Germination is good, and plant production is good (Table 4).

The Rosebud smut and gray shale sections of this drill hole were mixed together, making an interpretation difficult. However, the sample appeared favorable except for a slow infiltration rate.

The gray shale portion of this drill hole appears to be nontoxic, but has a low rate of infiltration, making it unsuitable for a plant growth medium, especially on undulating mine spoils.

Drill Hole B-3

Drill hole B-3 contained a brown sand for 10 feet, Rosebud smut for 2 feet, gray shale for 7 feet, and then McKay coal.

The brown sand from this hole appears to be an excellent material to be placed on the top of mine spoils, having no detrimental characteristics (Figure 3).

The Rosebud smut had some gray shale mixed in it, making it a more suitable material but not amenable to good plant production (Table 5).

The gray shale from this drill hole had good plant growth and production, permeability, germination, and chemical characteristics (Table 6). However, textural qualities were poor but were not

reflected in the permeability test.

Drill Hole F-1

Drill hole F-1 contained a brown sand for 19 feet, Rosebud smut for 3 feet, Rosebud coal for 11 feet, gray shale for 29 feet, and then McKay coal. Only three samples were obtained from this hole, so the results are an average of each type of material.

The brown sand from this drill hole has excellent physical and chemical characteristics (Figure 4) but supported a very poor plant growth (Table 7).

The Rosebud smut layer was not sampled, and only two samples were obtained from the deep layer of gray shale. The upper portion of gray shale was found to be impermeable, but the lower portion was not. Mechanical characteristics were not good for either depth of gray shale, and plant germination was poor (Table 8). This layer would not be recommended for spoil surfaces because of poor infiltration.

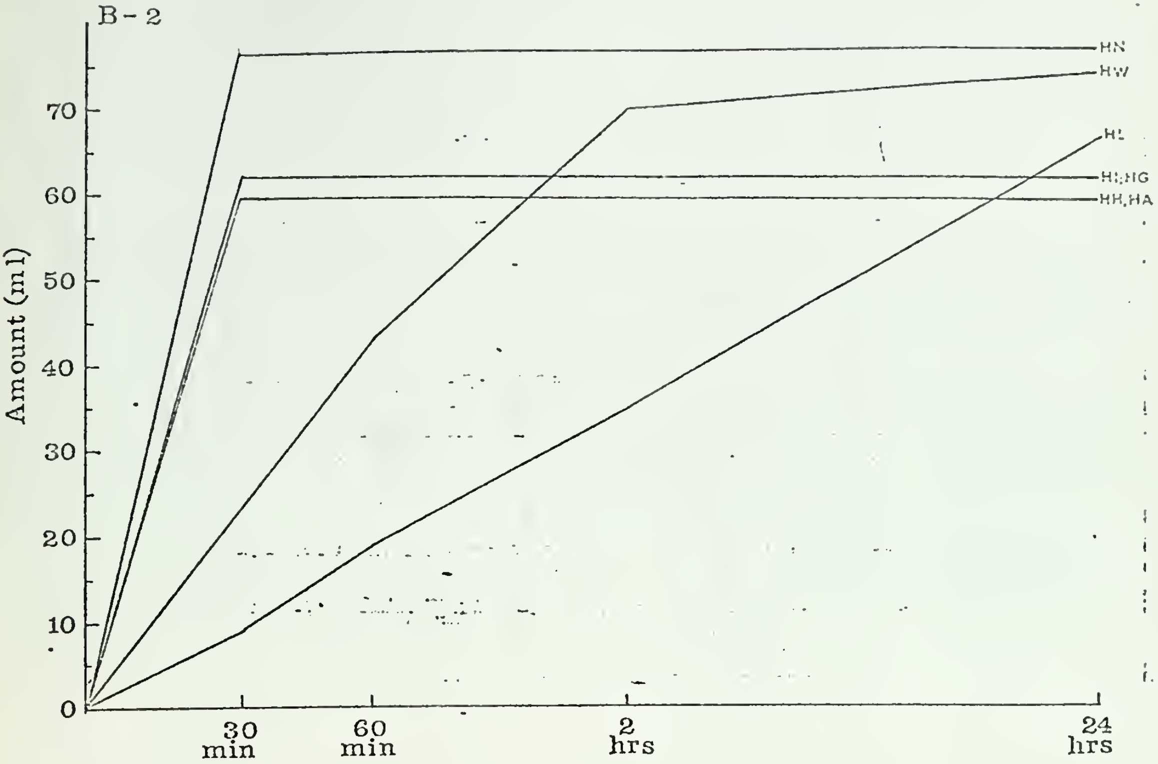

Figure 2. Rate of water flow through permeability test appartus for samples from Line B hole No. 2.

Depth (ft)	Leachate						Soil								Code
	pH	E.C.	Salts	Na	Total	SAR	pH	P	K	Na	Salts	Sand	Silt	Clay	
5-15	7.0	4300	2780	17.39	49.29	3.51	8.3	3	55	1.67	4.9	73	11	16	HH
10-15	7.9	5600	3520	24.80	57.61	4.62	8.5	13	95	2.41	5.8	61	16	23	HA
15-20	5.5	6000	3910	20.2	72.56	3.36	8.3	5	65	1.91	8.2	56	32	12	HG
20-25	8.1	1600	1035	7.8	11.70	3.25	8.6	3	25	.96	1.1	81	8	11	HT
25-30	7.7	900	576	2.1	6.88	1.13	8.5	13	25	.76	1.1	51	30	19	HW
31-40	7.7	1100	706	1.9	8.86	.91	8.4	13	25	.64	2.5	23	40	37	HL
49-50	8.0	700	450	1.6	5.52	.99	8.2	23	75	.91	1.7	33	34	33	HN

Table 4. Physical characteristics and production of Line B Hole No. 2 overburden.

Depth (ft)	Sat. Time (min:sec)	% Moisture at F.C.	Germination (%)	(mm) Leaf Length	Productivity (g/pot)	Code
5-15	13:05	24.9	100	515	.758	HH
10-15	11:25	26.4	100	514	.743	HA
15-20	11:40	24.0	100	429	.723	HG
20-25	11:15	22.7	92	376	.838	HT
25-30	9:14	9.9	100	511	.670	HW
31-40	12:05	13.2	100	592	.638	HL
49-50	3:15	3.2	58	674	.788	HN

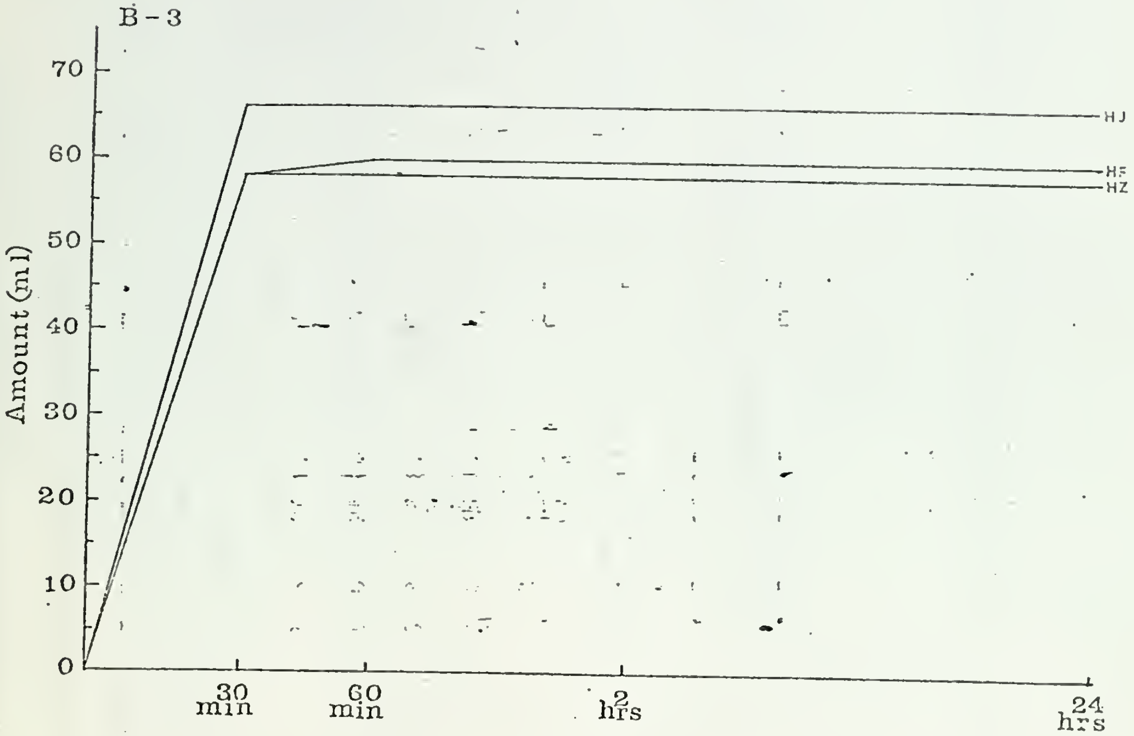

Figure 3. Rate of water flow through permeability test apparatus for samples from Line B hole No. 3.

Table 5. Physical and chemical characteristics of Line B Hole No. 3. overburden.

	Leachate						Soil								
Depth (ft)	pH	E.C.	Salts	Na	Total	SAR	pH	P	K	Na	Salts	Sand	Silt	Clay	Code
9-10	8.5	290	184	.68	2.15	.67	9.2	13	75	.64	1.0	27	54	19	HF
10-14	7.8	1900	1225	1.67	19.97	.52	8.4	8	45	.67	2.1	65	15	20	HZ
14-19	6.9	3000	1945	2.12	38.21	.48	8.3	10	35	.64	1.3	22	40	37	HJ

Table 6. Physical characteristics and production of Line B Hole No. 3 overburden.

Depth (ft)	Sat. Time (min:sec)	% Moisture at F.C.	Germination (%)	(mm) Leaf Length	Productivity (g/pot)	Code
9-10	12:55	25.4	100	349	.743	HF
10-14	12:35	26.0	100	453	.608	HZ
14-19	10:25	19.0	100	684	.860	HJ

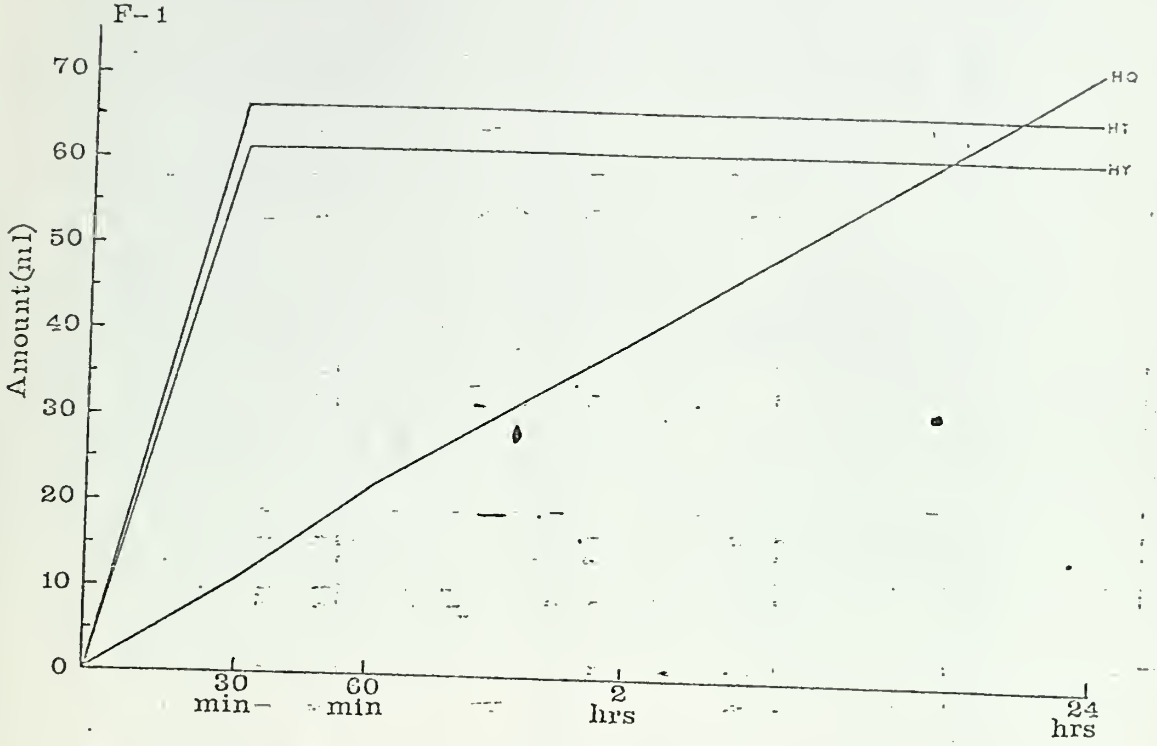

Figure 4. Rate of water flow through permeability test apparatus for samples from Line F hole No. 1.

Table 7. Physical and chemical characteristics of Line F Hole No. 1 overburden.

Depth (ft)	Leachate						Soil								Code
	pH	E.C.	Salts	Na	Total	SAR	pH	P	K	Na	Salts	Sand	Silt	Clay	
5-18	7.6	600	384	1.71	3.82	1.24	8.9	5	45	.72	2.1	69	14	17	HY
32.6-45	8.0	460	293	.82	3.26	.67	8.9	3	45	.59	2.0	21	58	21	HQ
45-58	7.2	800	512	1.30	5.64	.79	8.4	10	105	.85	4.9	10	35	55	HT

Table 8. Physical characteristics and production of Line F Hole No. 1 overburden.

Depth (ft)	Sat. Time (min:sec)	% Moisture at F.C.	Germination (%)	(mm) Leaf Length	Productivity (g/pot)	Code
5-18	12:20	23.5	100	425	.475	HY
32.6-45	11:10	4.6	83	478	.763	HQ
45-58	11:20	14.0	75	676	.958	HT

Drill Hole F-2

Drill hole F-2 is comprised of 9 feet of brown sand, 2 feet of Rosebud smut, 4 feet of gray sand, 3 more feet of brown sand, 7 feet of brown shale, 10 feet of gray shale, and then McKay coal. One sample was obtained from each layer.

The brown sand layer appears to be an excellent plant growth medium except for high salts in the leachate analysis (Figure 5) (Table 9).

The Rosebud smut and gray sand layers were high in salts and had slow infiltration rates.

The brown shale layer had a slow infiltration rate, and a very low moisture percentage at field capacity (Table 10).

The gray shale layer had very poor textural qualities with 9% sand, 40% silt and 51% clay. This sample was moderately impermeable and had a very low moisture percentage at field capacity.

Drill Hole F-3

Drill hole F-3 contained 14 feet of brown sand, 2 feet of Rosebud smut, 3 feet of brown sand and shale, 3 feet of gray sand and shale, and then McKay coal. One sample was obtained from each overburden layer.

The brown sand layer of this drill hole appears to be an excellent plant growth medium, with very good physical and chemical qualities (Figure 6) (Table 11).

The Rosebud smut layer showed a very high salt and sodium content in the leachate analysis.

The brown sand and shale portion had good chemical and physical qualities, but was high in salts and sodium in the leachate analysis,

and produced poor plant growth (Table 12).

The gray sand and shale layer provided good plant growth, but had poor textural qualities.

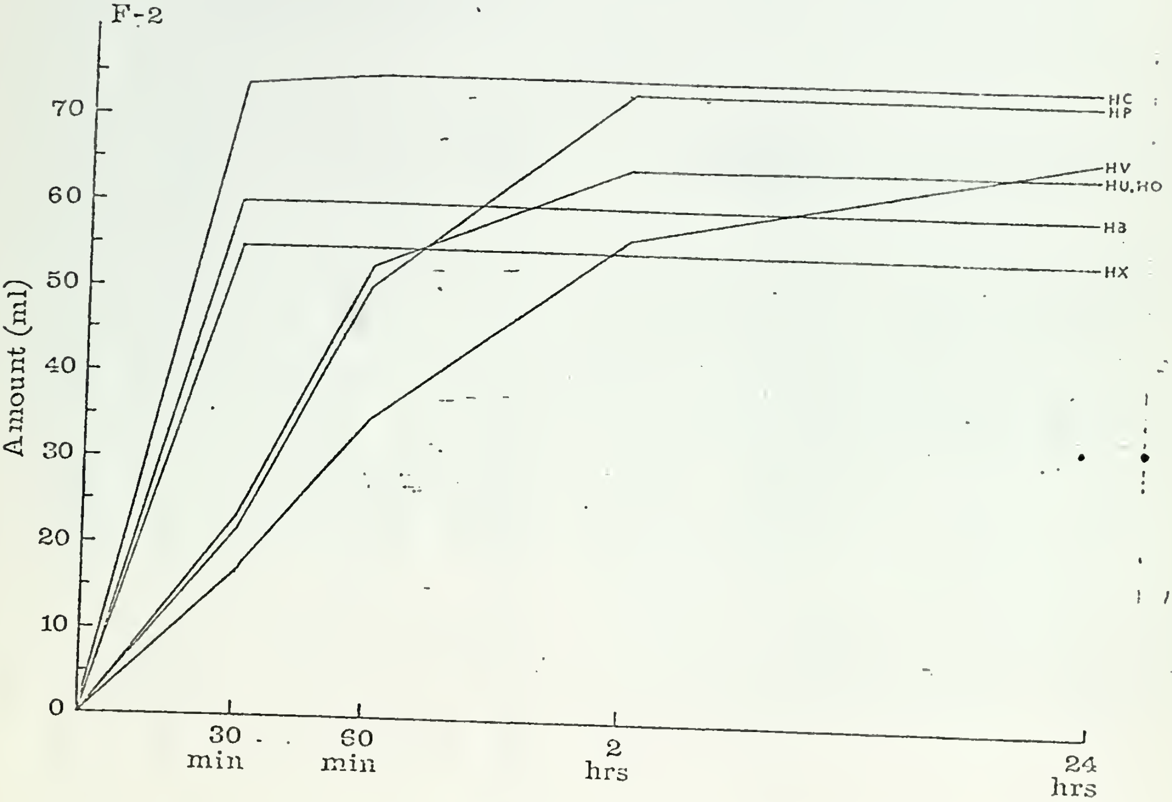

Figure 5. Rate of water flow through permeability test apparatus for samples from Line F hole No. 2.

Table 9. Physical and chemical characteristics of Line F Hole No. 2 overburden.

	Leachate						Soil								
Depth (ft)	pH	E.C.	Salts	Na	Total	SAR	pH	P	K	Na	Salts	Sand	Silt	Clay	Code
5-9	7.4	7500	4875	30.43	81.33	4.77	8.8	10	55	2.98	1.2	47	26	27	HB
9-12	7.3	16000	10500	79.35	234.14	7.33	8.6	13	45	4.24	0.2	51	42	7	HX
12-16	6.0	5300	3410	13.48	67.42	2.32	8.5	5	15	1.27	6.4	47	36	17	HU
16-19	7.8	2500	1615	11.30	22.17	3.40	8.5	5	35	1.35	3.4	21	52	27	HV
20-23	7.3	1800	1160	3.61	17.04	1.24	8.7	8	15	1.07	2.4	23	52	25	HP
23-26	8.0	700	450	1.55	4.45	1.05	8.7	3	55	.96	0.6	27	54	19	HC
26-35	7.6	2000	1293	3.65	19.34	1.18	8.5	10	85	.85	2.4	9	40	51	HO

Table 10. Physical characteristics and production of Line F Hole No. 2 overburden.

Depth (ft)	Sat. Time (min:sec)	% Moisture at F.C.	Germination (%)	(mm) Leaf Length	Productivity (g/pot)	Code
5-9	12:00	25.4	83	543	.915	HB
9-12	12:14	25.6	83	649	.550	HX
12-16	10:40	20.0	100	594	.680	HU
16-19	9:47	15.8	100	572	.765	HV
20-23	10:00	7.7	100	545	.808	HP
23-26	7:10	10.3	100	547	.868	HC
26-35	13:15	7.2	100	635	.793	HO

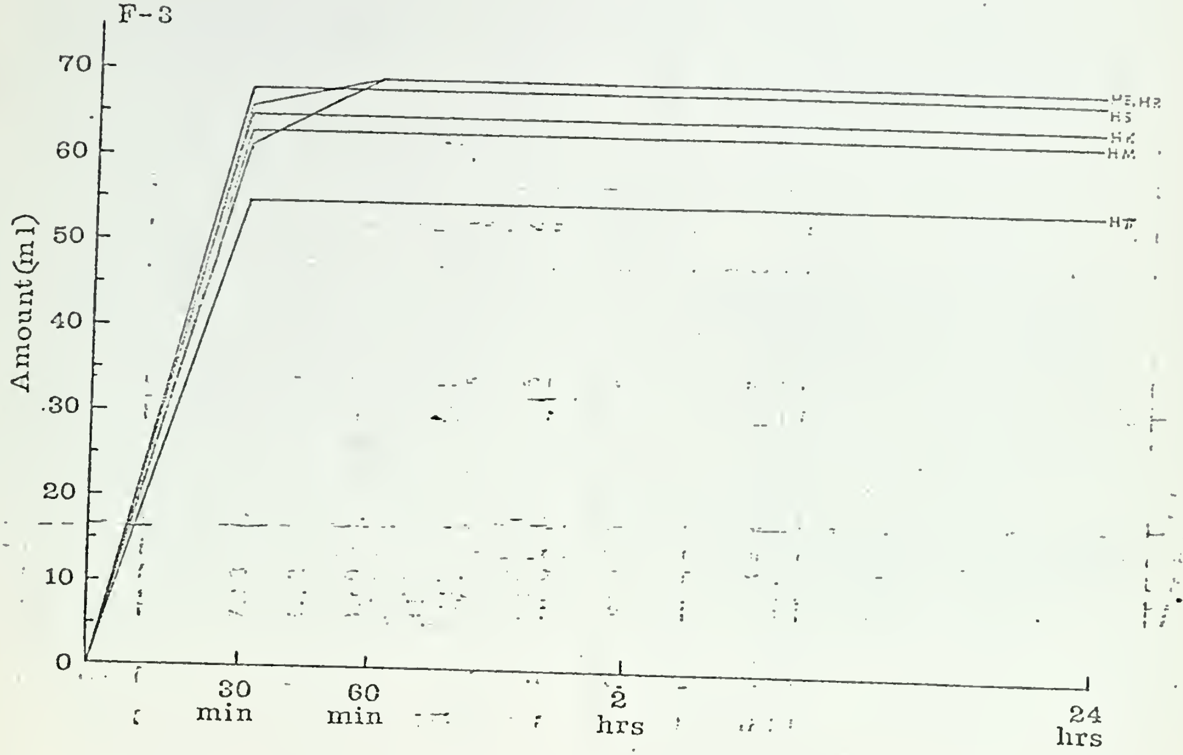

Figure 6. Rate of water flow through permeability test apparatus for samples from Line F hole No. 3.

Table 11. Physical and chemical characteristics of Line F Hole No. 3 overburden.

Depth (ft)	Leachate						Soil								Code
	pH	E.C.	Salts	Na	Total	SAR	pH	P	K	Na	Salts	Sand	Silt	Clay	
5-10	8.2	370	235	2.10	1.45	2.50	8.9	1	65	.87	.7	57	19	24	HK
10-14	7.9	2100	1350	1.30	5.64	.79	8.9	5	45	1.31	.3	54	23	23	HM
14-15	7.7	10000	6580	24.78	157.45	2.79	8.3	3	35	2.46	13.0	37	56	7	HY
16-18	7.6	4400	2850	7.83	56.87	1.46	8.1	3	25	1.27	.7	67	28	5	HE
18-20	7.3	3400	2200	3.79	41.24	.83	8.4	10	25	.96	.4	31	42	27	HR
20-22	8.1	1300	838	2.26	12.38	.91	8.4	3	105	1.07	1.2	17	34	49	HS

Table 12. Physical characteristics and production of Line F Hold No. 3 overburden.

Depth (ft)	Sat. Time (min:sec)	% Moisture at F.C.	Germination (%)	(mm) Leaf Length	Productivity (g/pot)	Code
5-10	10:55	15.2	83	428	.778	HK
10-14	11:00	16.3	100	484	.558	HM
14-16	13:00	26.2	92	609	.733	HY
16-18	9:35	16.2	100	439	.560	HE
18-20	12:00	35.3	100	568	.783	HR
20-22	10:00	12.3	100	572	.838	HS

Discussion

Most of the brown sand between the Rosebud and McKay croplines demonstrated acceptable physical and chemical properties for use as spoils surface materials without serious detrimental qualities. However, a high salt and sodium content were occasionally exhibited in the leachate analyses. This material should serve well as subsoil medium on which to apply good quality topsoil. This overburden material could be used on the surface as a soils substitute with reasonable assurance of water infiltration and plant growth. Plant growth would be dependent on supplying essential plant nutrients.

The Rosebud smut layer appeared to be a very poor plant growth medium, mainly because of its inconsistent physical and chemical characteristics. It was impermeable in many cases, and would not be recommended for use on the surface of spoils. It should instead be deeply buried.

The gray shale portion had good chemical characteristics, and usually supported excellent plant growth. However, its textural qualities were usually too low in sand, resulting in a low rate of infiltration. If this material must be left on the surface of mine spoils, it should be done only in conjunction with a water erosion control system such as a surface manipulation treatment, mulching, or deep topsoiling. This material would be better buried under brown sand or if necessary it could be used as a brown sand - gray shale mixture.

All samples were low in plant nutrients, and would surely require a nitrogen-phosphorus fertilizer application to support a varied plant growth cover. As expected, none of the samples produced as much plant growth as the greenhouse soil used as a control. Research studies

indicate that seedings on new spoils respond dramatically to nitrogen and phosphorus fertilizers.

[illegible]

Appendix A. Discussion of saline-alkaline soils.

Most saline and alkaline soils are the result of deposition of salts during evaporation from a water table. The high water table in some cases no longer exists, but rainfall may have been insufficient to remove the salts. Occasionally salinity results from a high salt parent material, usually a marine shale.

Saline soil conditions are generally classified by the electrical conductivity of the saturation extract (EC_e) which is a function of the salt content of the soil. The saturation extract is related to the water holding capacity of the soil, usually being about twice the field capacity. The significance of electrical conductivity is that it is a measure of the salt content of the extract, and can be related to plant growth on the soil. Research has shown that the yields of many crops are restricted if the conductivity of the saturation extract exceeds 4 millimohs per centimeter, and the soil is considered to be saline. Three theories or categories of physiological effects of salts on plant growth have been studied: (1) soluble salts decrease the availability of water to plants by increasing solute suction; (2) salts act within the plant by lowering the free energy of internal water and preventing physiological processes that require water, and (3) some ions are directly toxic to plants.

Soils that have excessive concentrations of sodium are called alkaline. Ca and Mg are the principal cations found in the soil solution and on the exchange complexes of normal soils in arid regions. When excess soluble salts accumulate in these soils, Na frequently becomes the dominant cation in the soil solution. Thus, sodium may

be the predominant cation to which the soil has been subjected, or it may become dominant in the soil solution, because of the precipitation of Ca and Mg compounds. As the soil solution becomes concentrated through water absorption by plants or evaporation, the solubility limits of $CaSO_4$, $CaCO_3$, and $MgCO_3$ are often exceeded, in which case they are precipitated with a corresponding increase in the relative proportion of Na. Under such conditions, a part of the original exchangeable Ca and Mg is replaced by Na. At equivalent solution concentrations, the amounts of Ca and Mg adsorbed are several times that of Na. In general, half or more of the soluble cations must be Na before significant amounts are adsorbed by the exchange complex. Therefore, a measurement of the ratio of Na to Ca and Mg is important in predicting the amount of Na that will be present on the exchange complex. Sodium-adsorption-ratio (SAR) is a measurement of this ratio, and can be used in locating soils that have high enough concentrations to be detrimental to plant growth. Soils having SAR values greater than 10 are considered alkaline, and usually produce decreases in plant growth. High Na decreases plant growth by affecting plant nutrition, and the physical properties of the soil. Alkaline soils usually have a very much reduced permeability.

APPENDIX #3

PEABODY COAL COMPANY
BIG SKY MINE
SOIL SURVEY

By

John L. Parker
Soil Scientist

Lambeth Series

The Lambeth Series consists of moderately deep strongly sloping well drained soils. The soils formed in loamy material weathered from silty, clayey and sandy shales, under a 10 to 16 inch annual precipitation. The mean annual soil temperature ranges from 40 to 45 degrees F. and the mean summer temperature is 66 to 72 degrees F. The natural vegetation is mixed grasses, forbs, and shrubs. The frost free season is 90 to 110 days.

The surface layer for 6 inches is light colored silt loam over a lightly yellowish brown thinly laminated calcareous silt loam subsoil. The natural fertility and organic matter content is medium in the surface layer and low in the substratum. Permeability is moderate.

A representative profile of Lambeth silt loam.

Typifying Pedon:

A1–0–6 inches, grayish brown (2.5y 5/2) silt loam, dark grayish brown (2.5y 4/2) moist weak fine platy structure separating to weak very fine granular structure; slightly hard, friable, nonsticky, nonplastic; many fine and very fine roots and pores; strongly effervescent; mildly alkaline, pH 7.4 to 7.8; gradual boundary.

C1ca–6–18 inches, light yellowish brown (2.5y 6/3) silt loam, light olive brown (2.5y 5/3) moist; massive, slightly hard, friable, nonsticky, nonplastic; many very fine roots and pores strongly effervescent; moderately alkaline pH 7.9 to 8.4 few splotches, seams and threads of segregated lime; diffused boundary.

C2ca–18–48 inches, pale yellow (2.5y 7/3) silt loam, light olive brown (2.5y 5/3) moist; massive; slightly hard friable; slightly effervescent; moderately alkaline; pH 7.9 to 8.0 few segregations of lime in seams, threads and splotches. Few nests of Gypsum crystals at 60 inches.

Depth to bedrock is greater than 5 feet. The surface layer ranges from a fine sandy loam to loam.

Lambeth soils are classified according to the 7th approximation as: Ustic Torriorthents, fine-silty, mixed, calcareous, frigid family.

Surface layer depth ranges from 4 to 7 inches thick, and depth of removal for stripping ranges from 18 to 20 inches.

Sample is designated on map as Ⓢ#1.

200 Lambeth silt loam

This unit occurs on gently to strongly sloping uplands below sandstone areas. The soil profile characteristics are those described as representative for the series.

The mapping unit consists of 95 percent Lambeth soils with small inclusions of Yawdim and Tullock soils. The included soils are less than 5 acres in size and only occupy 5 percent of the unit.

The unit is well drained, runoff is medium to slow and permeability is moderate. The available water holding capacity is moderate.

The unit is range. Erosion hazards slight.

600 Lambeth - Tullock Complex

The unit occurs on gently to strongly sloping uplands. The soil profiles are similar to those described as representative for each series.

The unit consists of 65 percent Lambeth soils and 30 percent Tullock soils, with small inclusions of Yawdim soils. The included soils are less than 5 acres in size and less than 5 percent of the area. The unit is well drained, runoff is slow and permeability moderate.

The available water holding capacity is moderate to low. Erosion hazards moderate.

The unit is range.

Ringling Series

The Ringling Series consists of shallow gently to strongly sloping well drained soils. The soils formed in loamy material weathered from deep porcelanite shale beds, under 10 to 16 inch annual precipitation. The mean annual soil temperature ranges from 44 to 46 degrees F. The mean summer temperature is greater than 62 degrees F. The frost free season is 90 to 110 days. The natural vegetation is mixed grasses, forbs, shrubs and pine.

The surface layer is reddish gray slaty loam over a very channery porcelanite bedrock. The natural fertility and organic matter content is medium. Permeability is moderate to rapid.

A representative profile of Ringling slaty loam.

Typifying Pedon:

A1-0-6 inches, reddish gray (5y 5/2) slaty loam, 15 to 20 percent porcelanite fragments, dark brown (5y 3/2) moist; weak fine crumb structure; soft, very friable, nonsticky, nonplastic; many fine and very fine roots and pores; neutral pH 6.5 to 7.2; clear wavy boundary.

C1-6-15 inches, pale red (10r 6/2) very gravelly loam, 50 to 80 percent porcelanite fragments, weak red (10r 4/2 mottles of weak red 10r 5/3 dusky red 10r 3/3) massive; soft, very friable, nonsticky, nonplastic; many fine and very fine roots matted between fragments and plates of shale; neutral; pH 6.5 to 7.2; abrupt boundary.

R-15-48 inches, fractured bedrock of reddish colored porcelanite shale.

Depth to hard porcelanite shale ranges from 14 to 18 inches. Percentage of porcelanite fragments ranges from 15 to 20 percent in the surface layer to as much as 85 percent in the C1 horizon. Lime may occur at 15 inches in depth in some profiles. It appears on the underside of the shale fragments. Loam this the dominant texture.

Ringling soils are classified according to the 7th approximation as: Lithie Haploborolls, loamy-sketetal mixed family.

Depth of surface soil ranges from 4 to 7 inches. Removal layer for stripping is between 4 to 5 inches.

Sample is designated on map as Ⓢ#4.

100 Ringling staly loam

This soil occurs on gently to strongly sloping divides and mesa like areas. The soil profile characteristics are those described as representative for the series.

The mapping unit consists of 95 percent Ringling soils with inclusions of Tullock and Lambeth soils. The included soils are less than 5 acres in size and occupy 5 percent of the area.

The mapping unit is well drained with slow runoff and moderate to rapid permeability. The available water holding capacity is moderate, about .63 to 2.00 inches per hour.

The unit is used for range. Erosion hazard slight.

Tullock Series

The Tullock Series consists of moderately deep moderate to strongly sloping well drained soils. The soil formed in sandy materials weathered from sandstone shale, under a 10 to 16 inch annual precipitation. The mean annual soil temperature ranges from 45 to 47 degrees F., and the mean annual summer temperature is 60 to 75 degrees F. The natural vegetation is mixed grasses, forbs, shrubs and scattered pine.

The surface layer for 6 inches is a light colored fine sandy loam underlain by light yellowish brown fine sandy loam. The natural fertility and organic matter is medium in the surface layer and low in the substratum. Permeability is moderately rapid.

A representative profile of Tullock fine sandy loam.

Typifying Pedon:

A1-0-8 inches, grayish brown (2.5y 5/2) fine sandy loam, dark grayish brown (2.5y 4/2) moist; weak fine granular structure; soft, friable, nonsticky, nonplastic; many fine and very fine roots and pores; neutral pH 6.6 to 7.3, clear boundary.

C1-8-24 inches, light yellowish brown (10 yR 6/4) fine sandy loam, yellowish brown (10yR 5/4) moist; massive; soft, friable, nonsticky, nonplastic, few fine roots; strongly effervescent; mildly alkaline pH 7.4 to 7.8. Clear boundary.

C2-24-48 inches, brownish yellow (10yR 6/6) fine sandy loam, pale yellow (2.5y 7/4) moist; massive, soft, friable, nonsticky, nonplastic; violently effervescent, moderate alkaline pH 7.9 to 8.4.

Surface layer thickness ranges from 6 to 10 inches. Removal of topsoil can be between 16 to 20 inches. Texture ranges from loamy sand to fine sandy loam.

Tullock soils are classified according to 7th approximation as Ustic Torripsamments, mixed, family.

Sample is designated on map as S #2.

700 Tullock fine sandy loam

This unit occurs on moderate or strongly sloping uplands. The soil profile characteristics are representative of the series.

The mapping unit consists of 95 percent Tullock soil and 5 percent Yawdim soils. The included soils are less than 5 acres in size.

The unit is well drained, runoff is slow and permeability is rapid. The available water holding capacity is low. Erosion hazard is slight. The unit is range.

500 Tullock - Yawdim Complex

This mapping unit occurs on moderately to steeply sloping uplands. The soil profile characteristics are similar to those described as representative for each series.

The mapping unit consists of 75 percent Tullock soils, 20 percent Yawdim soils and 5 percent Lambeth soils.

The unit is well drained, runoff is slow and erosion hazard moderate. The available water holding capacity is low. The unit is range.

Yawdim Series

The Yawdim Series consists of shallow moderately or strongly sloping and steep well drained soils. The soils formed from loamy materials weathered from silty, clayey and sandy shale, under a 10 to 16 inch annual precipitation.

The mean annual soil temperature is 45 to 47 degrees F. and a mean summer temperature of 65 to 70 degrees F. The frost free season is 90 to 110 days.

The surface 4 inch layer is a light brownish gray silty clay loam underlain by siltstone, sandstone and clay shale. The natural fertility and organic matter content is low. Permeability is slow.

A representative profile of Yawdim silty clay loam.

Typifying Pedon:

A1-0-4 inches, light brownish gray (2.5y 6/2) silty clay loam, dark grayish brown (2.5y 4/2) moist; weak fine platy to granular structure; hard, friable, sticky, plastic; slightly effervescent; mildly alkaline; pH 7.4 to 7.8; clear wavy boundary.

C1-4-16 inches, light yellowish brown (2.5y 6/4) silty clay loam, light olive brown (2.5y 5/6) moist; massive; hard, friable, sticky, plastic, few unweathered shale fragments, strongly effervescent; moderately alkaline pH 7.9 to 8.4. Abrupt boundary.

R-16+ light olive mottled shale.

Surface layer ranges from 3 to 6 inches. Removal layer for stripping is between 10 and 12 inches. Depth to shale bedrock ranges from 10 to 20 inches.

Yawdim soils are classified according to the 7th approximation; Typic Usticiorthent, clayey, mixed, calcareous, frigid family.

Sample is designated on map as Ⓢ#3.

300 Yawdim - Rockoutcrop Association:

This mapping unit is an association of Yawdim soils and sandstone rockoutcrops. The predominant features of the unit is the high percentage of barren shale and sandstone outcroppings. The steep sandstone cliffs are sometimes capped with a red porcelinate shale.

The unit is very steep. The Yawdim soils occupies the narrow divides and bench areas of the unit. The occurance of other soils are not predictable in the landscape. Runoff is rapid and erosion hazard severe; permeability is slow. Available water holding capacity is very low. The unit is used for range.

800 Mined Undifferentiated Area

This area is the mined area that is being reclaimed. The soil is undifferentiated.

400 Alluvial Lands

This unit consists of deep Alluvial soils on flood plains of the streams. They consist of undifferentiated material. The soil will range from very deep to shallow. The stream channel has meandered through the unit.

The soil material consists of old and recently laid material.

ene

When you get the reports on each soil Series from MSU. You will have enough nformation to answer any question on topsoiling.

Each series as found in the proposed rea was described for 4 feet by horizons. lso the soil suitable for topsoil is listed r each Series.

I am sure there are no harmful lements in the topsoil of any series hat will prevent plant growth. The ils of the area have lime which will d in plant growth.

John L. Parker

P.O. Forsyth, MT 59327

County Rosebud

County Agent Leroy L. Vossler

Extra copy to John L. Parker, 2012 John Adams Parkway, Idaho Falls, ID 83401

Plant and Soil Science Department
Montana State University
Bozeman, Montana 59715

Date received in lab. 7/16/73

Date sent by lab. 7/20/73

Lab No.	Your Field No.	pH	Organic Matter %		Nitrate Nitrogen ppm	Phosphorus P ppm		Potassium K ppm		Calcium Ca* meq/100g	Magnesium Mg* meq/100g	Sodium Na* meq/100g	Salt Hazard mmhos		Soil Texture
19	1	7.8	.81	vl		20	vl	105	l	35.40	6.81	.44	0.5	Ok	Sandy Loam
20	2	8.4	.25	vl		1	vl	115	l	33.80	6.72	.51	0.4	Ok	Sandy Loam
21	3	8.2	1.7	vl		1	vl	85	l	36.20	8.53	.44	0.6	Ok	Clay Loam
22	4	8.4	1.7	vl		1	vl	215	m	34.60	6.23	.39	0.4	Ok	Sandy Loam

OTHER TESTS REQUESTED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	

LEGEND

RATING

vl	very low
l	low
m	medium
h	high
<	less than
>	more than

1 acre of soil 6-7" deep is 2 million pounds. ppm = pounds per 1 million pounds. Therefore 2 × ppm is pounds per acre (2 million pounds).

* Ca, Mg and Na are reported as milliequivalents/100 g of soil. To convert these to ppm, use the following: ppm Ca = meq of Ca × 200; ppm Mg = meq Mg × 122; ppm Na = meq Na × 230.

FERTILIZER SUGGESTIONS — LBS/A

Sample	Crop	Year	N	$P_2O_5 \times .44 = P$		$K_2O \times .83 = K$		

REMARKS (See Fertilizer Guide Sheet Enclosed)

I would suggest [illegible]
[illegible]
[illegible]

ST - Form 2

Distribution of copies
white - sample owner yellow - county agent pink - extension soils
green - extra blue - soil testing lab

County Agent LeRoy [illegible] Date Completed

Agricultural Experiment Station MONTANA STATE UNIVERSITY Cooperative Extension Service

APPENDIX #4

SOIL SURVEY AND MAPPING

HORIZON ANALYSES

OVERBURDEN ANALYSES

By

Montana Testing Laboratories, Inc.

REPORT OF

I

SOIL SURVEY AND MAPPING

II

HORIZON ANALYSES

III

OVERBURDEN ANALYSES

for

EVALUATION OF REVEGETATION POTENTIAL

PROVIDED BY

MONTANA TESTING LABORATORIES INC.

REPORT 7 B-1

# DESCRIPTIONS OF SOIL SERIES
for
SOIL SURVEY OF PEABODY COAL COMPANY
BIG SKY MINE NEAR COLSTRIP, MONTANA

Soil Survey Prepared by
John L. Parker
and
Completed by Montana Testing Laboratories

James Meshnick	Soil Scientist
Ernest Hogan	Soil Scientist
Raymond T. Choriki	Soils Specialist

HOW THIS SURVEY WAS MADE

Soil scientists made this survey to learn what kind of soil are in the Colstrip area, where they are located, and to what extent each soil can be stockpiled for reclaiming the land after strip mining. The soil scientists went into the area knowing they likely would find many soils they had already seen and perhaps some they had not seen. They observed the steepness, length , and shape of the slopes, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil. It extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The soil series and the soil phase are the categories of soil classification most used in this survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Cushman and Elso, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affect use of the soil by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, McRae loam is one of several phases within the McRae series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show drainages, buildings, field borders, trees, and other details that help to draw boundaries accurately. The soil boundaries were later transferred to the accompanying topographic map which is drawn to a scale of 1" = 200'. Countour interval is 5 feet.

In most areas surveyed, there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. In the Colstrip area a miscellaneous land type is in complex with a soil. An example of this is Shale Outcrop-Elso complex, very steep.

While the soil survey was in progress, soil scientists took soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled.

IDENTIFICATION LEGEND

PEABODY COAL COMPANY

map symbol	Soil Name	Depth in Feet Suitable For Stockpiling
100	Ringling Slaty Loam	0
200	Lambeth Silt Loam	2
300	Yawdim-Rock Outcrop Association	0
400	Alluvial Soils	5+
500	Tullock-Yawdim Complex	1-2
600	Lambeth-Tullock Complex	2
700	Tullock Fine Sandy Loam	2
800	Mined Undifferentiated Area	-

PROCEDURES FOR SOIL SAMPLING FOR LABORATORY ANALYSIS

Soil samples for laboratory analysis were collected from hand dug pits. Individual horizons, described and identified according to procedures outlined in Agriculture Handbook No. 18, Soil Survey Manual USDA, were sampled. Quart size samples were taken of each significant horizon from a vertical section of the pit. Horizons below 30 inches were sampled with a hand auger or mechanical soil probe.

Soil profiles were selected to represent the central concept of the soil series within the survey area where ranges in characteristics were small. Where soil characteristics ranged broadly the profiles were selected to represent the extremes.

USES OF THE SOIL SURVEY AND LABORATORY ANALYSIS

The soils map, together with the laboratory analyses of the soils within the survey area, furnish information useful in predicting soil behavior for several purposes. Engineers use the information in predicting stability of slopes on earth structures, ease of soil compaction, susceptibility to piping, permeability and corrosion of buried metals and concrete. Agronomists find the information useful in making estimates of kinds and amounts of usable material for reseeding mine areas; for crop selection and varieties, fertility treatments, and reclamation of soils with special chemical deficiencies. Land use planners can use the information in selecting and laying out building sites, parks, roads and industrial areas.

In conjunction with a range site survey, predictions can be made on suitability of the soils for growing native and introduced grass species.

GENERAL DESCRIPTION OF THE AREA

The soil survey of the Peabody Area is in southeastern Montana. It is a approximately 10 miles west and 40 miles south of Forsythe, Montana.

The vegetation includes western wheat grass, blue bunch wheat grass, neddle and thread, blue grass, sedges, prairie sansreed, Idaho fescue, and other desirable and undesirable species. Forb of various species are also present.

For this report major emphasis will be placed on the various soils that were mapped and the interpretation of the results of these soils for stockpiling purposes, which will be used to establish and maintain adequate cover growth after mining operations have ceased.

The legend for each soil series are shown in Exhibit 1 with the corresponding map symbol. The description for each horixon of all series are discussed separately. The soil analysis and interpretation are also discussed separately. The soil analysis and interpretation are also discussed in a separate report.

LAMBETH SERIES

The Lambeth Series consists of deep strongly sloping well drained soils. The soils formed in loamy material weathered from silty, clayey and sandy shales, under a 10 to 16 inch annual precipitation. The mean annual soil temperature ranges from 40 to 45 degrees F. and the mean summer temperature is 66 to 72 degrees F. The natural vegetation is mixed grasses, forbs, and shrubs. The frost free season is 90 to 110 days.

The surface layer for 6 inches is light colored silt loam over a lightly yellowish brown thinly laminated calcareous silt loam subsoil. The natural fertility and organic matter content is medium in the surface layer and low in the substratum. Permeability is moderate.

A representative profile of Lambeth silt loam.

Typifying Pedon:

A1-0-6 inches, grayish brown (2.5y 5/2) silt loam, dark grayish brown (2.5y 4/2) moist weak fine platy structure separating to weak very fine granular structure; slightly hard, friable, nonsticky, nonplastic; many fine and very fine roots and pores; strongly effervescent; mildly alkaline, pH 7.4 to 7.8; gradual boundary.

C1ca-6-18 inches, light yellowish brown (2.5y 6/3) silt loam, light olive brown (2.5y 5/3) moist; massive, slightly hard, friable nonsticky, nonplastic; many very fine roots and pores strongly effervescest; moderately alkaline-pH 7.9 to 8.4 few splotches, seams and threads of segregated lime; diffused boundary.

C2ca-18-48 inches, pale yellow (2.5y 7/3) silt loam, light olive brown (2.5y 5/3) moist; massive; slightly hard friable; slightly effervescent; moderately alkaline; pH 7.9 to 8.0 few segregations of of lime in seams, threads and splotches. Few nests of Gypsum crystals at 60 inches.

Depth to bedrock is greater than 5 feet. The surface layer ranges from a fine sandy loam to loam.

Lambeth soils are classified according to the 7th approximation as: Ustic Torriorthents, fine-silty, mixed, calcareous, frigid family.

Surface layer depth ranges from 4 to 7 inches thick, and depth of removal for stripping ranges from 18 to 20 inches.

Sample is designated on map as (S) #1.

200 Lambeth silt loam

This unit occurs on gently to strongly sloping uplands below sandstone areas. The soil profile characteristics are those described as representative for the series.

The mapping unit consists of 95 percent Lambeth soils with small inclusions of Yawdim and Tullock soils. The included soils are less than 5 acres in size and only occupy 5 percent of the unit.

The unit is well drained, runoff is medium to slow and permeability is moderate. The available water holding capacity is moderate.

The unit is range. Erosion hazards slight.

Recommendations for Stockpiling:

The upper 2 feet of this soil is suitable for stockpiling. Below this approximate depth gypsum salts are commonly visible making this soil unsuitable for stockpiling.

600 Lambeth - Tullock Complex

The unit occurs on gently to strongly sloping uplands. The soil profiles are similar to those described as representative for each series.

The unit consists of 65 percent Lambeth soils and 30 percent Tullock soils, with small inclusions of Yawdim soils. The included soils are less than 5 acres in size and less than 5 percent of the area. The unit is well drained, runoff is slow and permeability moderate.

The available water holding capacity is moderate to low. Erosion hazards moderate.

The unit is range.

Recommendations for Stockpiling:

The soil material above the bedrock or to a depth of about 2 feet, is suitable for stockpiling. Locally, on the lower slopes, these soils may be suitable to a depth of 3 or 4 feet. The deeper soils occur on the side slopes below and between the knolls and ridges.

The sandstone underlying the Tullock soil is low in organic matter and natural fertility. The silty shale underlying the Lambeth soil is slowly permeable and commonly contains gypsum salts.

RINGLING SERIES

The Ringling Series consists of shallow gently to strongly sloping well drained soils. The soils formed in loamy material weathered from deep porcelanite shale beds, under 10 to 16 inch annual precepitation. The mean annual soil temperature ranges from 44 to 46 degrees F. The mean summer temperature is greater than 62 degrees F. The frost free season is 90 to 110 days. The natural vegetation is mixed grasses, forbs,shrubs and pine.

The surface layer is reddish gray slaty loam over a very channery porcelanite bedrock. The natural fertility and organic matter content is medium. Permeability is moderate to rapid.

A representative profile of Ringling slaty loam.

Typifying Pedon:

A1-0-6 inches, reddish gray (5y 5/2) slaty loam, 15 to 20 percent porcelanite fragments, dark brown (5y 3/2) moist; weak fine crumb structure; soft, very friable, nonsticky, nonplastic; many fine and very fine roots and pores; neutral pH 6.5 to 7.2; clear wavy boundary.

C1-6-15 inches, pale red (10r 6/2) very gravelly loam, 50 to 80 percent porcelanite fragments, weak red (10r 4/2 mottles of weak red 10r 5/3 dusky red 10r 3/3) massive; soft, very friable, nonsticky, nonplastic; many fine and very fine roots matted between fragments and plates of shale; neutral; pH 6.5 to 7.2; abrupt boundary.

R-15-43 inches, fractured bedrock of reddish colored porcelanite shale.

Depth to hard porcelanite shale ranges from 14 to 18 inches. Percentage of porcelanite fragments ranges from 15 to 20 percent in the surface layer to as much as 85 percent in the C1 horizon. Lime may occur at 15 inches in depth in some profiles. It appears on the underside of the shale fragments. Loam is the dominant texture.

Ringling soils are classified according to the 7th approximation as: Lithic Haploborolls, loamy-skeletal mixed family.

Depth of surface soil ranges from 4 to 7 inches. Removal layer for stripping is between 4 to 5 inches.

Sample is designated on map as (S) #4.

100 Ringling slaty loam

This soil occurs on gently to strongly sloping divides and mesa like areas. The soil profile characteristics are those described as representative for the series.

The mapping unit consists of 95 percent Ringling soils with inclusions of Tullock and Lambeth soils. The included soils are less than 5 acres in size and occupy 5 percent of the area.

The mapping unit is well drained with slow runoff and moderate to rapid permeability. The available water holding capacity is moderate, about .63 to 2.0 inches per hour.

The unit is used for range. Erosion hazard slight.

Recommendations for Stockpiling:

Because of shallow depth to hard rock and the high percentage of coarse fragments above the bedrock, this soil is not suitable for stockpiling.

TULLOCK SERIES

The Tullock Series consists of moderately deep moderate to strongly sloping well drained soils. The soil formed in sandy materials weathered from sandstone shale, under a 10 to 16 inch annual precipitation. The mean annual soil temperature ranges from 45 to 47 degrees F., and the mean annual summer temperature is 60 to 75 degrees F. The natural vegetation is mixed grasses, forbs, shrubs and scattered pine.

The surface layer for 6 inches is a light colored fine sandy loam underlain by light yellowish brown fine sandy loam. The natural fertility and organic matter is medium in the surface layer and low in the substratum. Permeability is moderately rapid.

A representative profile of Tullock fine sandy loam.

Typifying Pedon:

A1-0-8 inches, grayish brown (2.5y 5/2) fine sandy loam, dark grayish brown (2.5y 4/2) moist; weak fine granular structure; soft, friable, nonsticky, nonplastic; many fine and very fine roots and pores; neutral pH 6.6 to 7.3, clear boundary.

C1-8-24 inches, light yellowish brown (10yR 6/4) fine sandy loam, yellowish brown (10yR 5/4) moist; massive; soft, friable, nonsticky, nonplastic, few fine roots; strongly effervescent; mildly alkaline pH 7.4 to 7.8. Clear boundary.

C2-24-48 inches, brownish yellow (10yR 6/6) fine sandy loam, pale yellow (2.5y 7/4) moist; massive, soft, friable, nonsticky, nonplastic; violently effervescent, moderate alkaline pH 7.9 to 8.4.

Surface layer thickness ranges from 6 to 10 inches. Removal of top soil can be between 16 to 20 inches. Texture ranges from loamy sand to fine sandy loam.

Tullock soils are classified according to 7th approximation as Ustic Torripsamments, mixed, family.

Sample is designated on map as S #2.

700 Tullock fine sandy loam

This unit occurs on moderate or strongly sloping uplands. The soil profile characteristics are representative of the series.

T The mapping unit consists of 95 percent Tullock soil and 5 percent Yawdim soils. The included soils are less than 5 acres in size.

The unit is well drained, runoff is slow and permeability is rapid. The available water holding capacity is low. Erosion hazard is slight. The unit is range.

Recommendations for Stockpiling:

All the soil above the bedrock is suitable for stockpiling. The soil depth is mainly about 2 feet but locally is 4 or 5 feet where slopes are concave or slope gradient is less than 6 percent.

Natural fertility and water holding capacity decrease rapidly below 12 inches.

The underlying sandstone in the upper foot is weathered sufficiently for excavation but is low in natural fertility and water holding capacity.

500 Tullock - Yawdim Complex

This mapping unit occurs on moderately to steeply sloping uplands. The soil profile characteristics are similar to those described as representative for each series.

The mapping unit consists of 75 percent Tullock soils, 20 percent Yawdim soils and 5 percent Lambeth soils.

The unit is well drained, runoff is slow and erosion hazard moderate. The available water holding capacity is low. The unit is range.

Recommendations for Stockpiling:

The soil material above the bedrock is suitable for stockpiling. The Tullock sandy loam in the complex, is suitable for stockpiling to a depth of about 2 feet. Locally it is suitable to a depth of 3 feet or more.

The Yawdim soil is suitable to a depth of about 1 foot. Below this approximate depth the underlying shale is slowly permeable and commonly has pockets of gypsum salts.

YAWDIM SERIES

The Yawdim Series consists of shallow moderately or strongly sloping and steep well drained soils. The soils formed from loamy materials weathered from silty, clayey and sandy shale, under a 10 to 16 inch annual precipitation.

The mean annual soil temperature is 45 to 47 degrees F. and a mean summer temperature of 65 to 70 degrees F. The frost free season is 90 to 110 days.

The surface 4 inch layer is a light brownish gray silty clay loam underlain by siltstone, sandstone and clay shale. The natural fertility and organic matter content is low. Permeability is slow.

A representative profile of Yawdim silty clay loam.

Typifying Pedon:

A1-0-4 inches, light brownish gray (2.5y 6/2) silty clay loam, dark grayish brown (2.5y 4/2) moist; weak fine platy to granular structure; hard, friable, sticky, plastic; slightly effervescent; mildly alkaline; pH 7.4 to 7.8; clear wavy boundary.
C1-4-16 inches, light yellowish brown (2.5y 6/4) silty clay loam, light olive brown (2.5y 5/6) moist; massive; hard, friable, sticky, plastic, few unweathered shale fragments, strongly effervescent; moderately alkaline pH 7.9 to 8.4. Abrupt boundary.
R-16+ light olive mottled shale.

Surface layer ranges from 3 to 6 inches. Removal layer for stripping is between 10 and 12 inches. Depth to shale bedrock ranges from 10 to 20 inches.

Yawdim soils are classified according to the 7th approximation; Typic Usticiorthent, clayey, mixed, calcareous, frigid family.

Sample is designated on map as (S) #3.

300 Yawdim - Rockoutcrop Association:

This mapping unit is an association of Yawdim soils and sandstone rockoutcrops. The predominant features of the unit is the high percentage of barren shale and sandstone outcroppings. The steep sandstone cliffs are sometimes capped with a red porcelinate shale.

The unit is very steep. The Yawdim soils occupies the narrow divides and bench areas of the unit. The occurrence of other soils are not predictable in the landscape. Runoff is rapid and erosion hazard severe; permeability is slow. Available water holding capacity is very low. The unit is used for range.

Recommendations for Stockpiling:

Because of the high percentage of rock outcrop, very shallow depth of soil and rough terrain, these areas have little or no soil that is suitable for stockpiling.

800 Mined Undifferentiated Area

This area is the mined area that is being reclaimed. The soil is undifferentiated.

400 Alluvial Lands

This unit consists of deep Alluvial soils on flood plains of the streams. They consist of undifferentiated material. The soil will range from very deep to shallow. The stream channel has meandered through the unit.

The soil material consists of old and recently laid material.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of at least 5 feet and is suitable below as deep as the material remains basically the same. Gravel and sand may be present at some depth in some places. A water table at some depth greater than 5 feet is generally present.

REPORT 7 B-2

PROJECT TITLE: SOIL ANALYSIS OF SOIL HORIZON FROM MAJOR SOILS PRESENT ON THE AREA OF OPERATION

JUSTIFICATION

Since reclamation of disturbed areas is now part of the mining operation, it is important to consider the soils aspect for revegetation purpose. Therefore, as part of the soil survey mapping project, soil was collected for analysis to determine stockpiling potential of all major soils on the operating area.

METHODS AND MATERIAL FOR TESTING

1. Sample Collection (See Prport A)
2. Sample Preparation

   Soil samples were air dried and split into two samples, one for chemical analysis and the remaining half was kept for later use. Each sample was passed through a 9 mesh screen for mechanical analysis and 20 mesh screen for chemical analysis.

3. Chemical and Physical Analysis

   The following determinations were carried out on horizon sample material after screening (20 mesh).

   aa pH - soil solution ratio 1:2.

   ab Conductivity - same as above.

   ac Sodium Adsorption Ratio (SAR) - If ammonium acetate soluble is greater than 1 me/100 gms.

   ad Cation Exchange Capacity - If SAR is greater than 10. Either exchangeable sodium percentage (ESP)or SAR could be used to predict physical problems in the future.

   ae Texture - Mechanical Analysis (Hydrometer Method) (screen size 9 mesh).

Macro Nutrients:

Organic Matter

Nitrate Nitrogen (Diphenyldisulphonic acid)

Phosphorous (weak bray - modified by Montana State University

Potassium, Calcium, Magnesium, and Sodium (ammonium acetate soluble)

Others:

Sulfur - (NH_4 acetate soluble)

Zinc, Iron, Manganese and Copper (Chelatable, DTPA extracted)

Boron - hot water soluble

RESULTS AND DISCUSSION (Stops #1 through #8)

pH and Soluble Salts

Electrical conductivity of the soil solution or extract is a function of the salt content of the soil and related to plant growth potential of each soil. The conductivity of these extracts are grouped for crops that are restricted to under 4 mmhos/cm or those that can exceed 8 mmhos/cm. Soil containing greater than 4 mmhos/cm is considered "saline" and will decrease plant growth and production. It is believed that salts generally affect plant growth either by (1) decreasing the availability of water to plants by increasing solute suction and causing the plant to require more energy to absorb and translocate water; (2) salts actwithin the plant by lowering the free energy of internal water and preventing physiological precesses that require water;and (3) some ions are directly toxic to plants.

Analyses were made for pH and soluble salts for four major soil series found in Area (Stop #1 through #3). The soluble salts of Tullock, Yawdim, Ringling and Lambeth series have very low soluble salts on most pedons. The only soil series with appreciable salts were found in the Lambeth series (200). The salts were found in the lower depth, 28" to 65" (Stop #5). This however, may not interfere with germination and growth because the levels are below 4mmhos/cm. The salt being present , however, suggests that there may be a layer of salt that coud be higher than analyzed. In the collection of the samples, the soil could possibly be mixed with a layer of high salt and layer of low salt thus diluting the condentration. The soil pH ranged from 7.5 to 8.9. This may not be a problem especially if sodium content in soil is low. High lime and sodium content normally account for higher pH value beyond 8.0.

Sodium Adsorption Ratio (SAR)

Soils that have excessive concentrations of sodium are called "alkali". When sodium becomes the dominant cation in the soil solution or the exchange complexes of soil, it will exceed 15% of the cation exchange capacity. The relative proportion of sodium increases as the calcium and magnesium activity decrease because of precipitation when soil solution becomes more concentrated. As the calcium and magnesium activity decrease, the sodium cation will become more dominant(greater than 50%) and replace calcium and magnesium cation on the exchange complex by "mass action". Therefore SAR is a measurement of this ratio and is used to locate and predict these problems that can be injurious for plant development. Soils having SAR greater than 10 are expected to have some problems and reclamation by correcting drainage and addition of gypsum or other amendments will be required. High sodium values will disperse the fine particles and cause crusting of soils and other poor physical properties associated with it.

Sodium content was below 1.0 me/100 gm of soil on all soil series except Lambeth silt loam (Stop #5). The ammonium acetate soluble sodium content was 3.1 me/100 gm and we expected to find SAR higher than others. However, the calcualted SAR values were 4.92 and is considered low and should expect no physical problems.

Cation Exchange Capacity

Cation Exchange Capacity is required to calculate eschangeable sodium percentage. SAR values were low and this was not required.

Texture

Textural analyses were made by both "feel" and hydrometer method. The particle size distribution for this area are found to be very desirable for permeability. Textures are classed as loamy sand (LS), sandy loam (SL), sandy clay loam (SCL), loam (L), and clay loam (CL). Ringling soil series contain very high percentage (35-50%) of gravel on the surface (2mm and greater) and should not be used for road beds. The texture found in this area, other than the Ringling series, have desirable characteristics for permeability and fair water holding capacity. The loamy sand and sandy loam will have lower water holding capacity as shown by the difference of .3 Bar to 15 Bar suction. These sandy soils will require frequent precipitation and higher level of plant nutrient requirement. It is desirable to add straw mulch for stand establishment to keep soil wet during germination period.

Macronutrients

Organic matter and nitrate nitrogen analyses were used to predict nitrogen requirement for revegetation potential. There was no consistency on organic matter level on all soils; but found nitrate nitrogen very low on all depths of all soils. Organic matter level will decrease if cultivated for a period of years and this could affect the levels. Organic matter decreases with depth and contains very little below the surface 10 inch layer. Supplemental nitrogen becomes a very important nutrient in establishment of any permanet cover.

Phosphorous($NaHCO_3$ Extraction Solution)

The levels below 4ppm are considered very low and expect a very good response from the application of phosphorous. The level of 4-9ppm is low, 8-10 ppm is medium and greater than 10 ppm is considered high. Phpsphorous analysis was found to be low or very low on soil samples analyzed. When the top soil is mixed with soil containing a higher level of phosphorous, it may increase level but it would not exceed the adequate level. Phosphorous becomes a very important supplemental nutrient in establishment of any permanent cover and should be considered in the reclamation procedure.

Potassium

The available potassium in these samples are generally close to 200 ppm level. The top 8 inches of soil in this area may contain an adequate level for grass established, but if it is mixed with lower depths supplemental potassium may be necessary.

Sulfur and Micronutrients

Variation in sulfur analyses obtained from each sample taken makes it difficult to predict the sulfur requirements in general. Sulfur may not be required even if subsoil is mixed with the top surface soil.

The micronutrient extractable in DTPA shows adequate level on all except zinc. A response can be expected when levels are below 0.5 ppm zinc. After mixing surface soil with lower depths, zinc may become an important nutrient for establishment of grass and maintaining growth.

Water Holding Capacity

Water holding capacity is determined by imposing 0.33 Bar and 15 Bar suction. The amount of water held between these two suctions is expressed as plant available water (PAW). The amount of water held in each soil is related to organic matter, amount of clay present, and structure. The sandy loam and loamy sand soils contain more sand and have very low water holding capacity as shown in the results. The difference between 0.33 Bar and 15 Bar suction of these soils is approximately 4-5%,while the soil containing higher clay will have as much as 15-20 % difference between the two suctions. The water holding capacity was determined by the equation developed by Dr. Gordon Decker.

RECOMMENDATION

Based on chemical and physical analyses of soil collected by horizon in the Area we would recommend stockpiling of soil for revegetation as two alternatives.

Alternative #1

Remove top 8-12" of soil and stockpile separately. When mining operation is completed and leveled, place top soil material on the surface with a minimum of 4" layer. Because there were no elements detrimental to growth on the top 8-12" of these soils we should anticipate satisfactory stand and adequate growth providing fertilizer is supplemented as required.

The organic matter decreases with depth below 8" on most soils and should consider stockpiling near 8-12" of the surface soil separately if possible. The lower depth (3-4') should also be stockpiled separately and used for fill above the overburden when mining operations cease. The soil below the top surface contains sandy material and could be mixed with some of the soil taken from lower depths that are very high in clay and silt to help improve texture if necessary.

The supplemental fertilizer should be 80-80-0 and possibly zinc. Nitrogen (40-0-0) should be applied annually until declared unnecessary. Annual application should help recycle nitrogen in the soil and may be declared unnecessary after several years. It may require additional phosphorous in 2 or 3 years. Please note: Soil samples taken after mining operation is completed, soil leveled and ready for seeding should be more appropriate time to predict the fertilizer requirement than before operation begins. I would strongly suggest a detail sample be taken before seeding of grasses to evaluate fertilizer requirement.

Alternative #2

Remove top 3-4' or less as indicated in the soil survey map and apply fertilizer to help establish stand and maintain permanent cover crop in the same manner as discussed in alternative #1. The stockpiling of 3-4' of these sandy materials can be advantageous if the overburden soil has high clay content that should be mixed to improve water intake and hydraulic conductivity. The fertilizer requirement will change if stockpiling is done in this manner.

These alternatives are not listed as priority in sequence given.

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal Horizon
Stop #1 Tullock

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
1703		0-2	7.8	3.5	0.5		2 5	213	22.4	2 5	0.1	0.3	FSL	M-
1704		2-8	7.9	1.3	0.25		1.1	150	33.7	3.8	0.1	0.3	L	M+
1705		8-14	8.0	0.1	0.25		0.5	88	+35	3.4	0.1	0.3	L	M+
1706		14-33	8.3	0.1	0.25		0.08	88	+35	8.2	0.1	0.5	VFSL	V-

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
								SAR					texture
11.3	4.0	1.6	6.4	0.3		8.25	4.13	1.3		12.8	20.4	66.8	SL
+138.0	0.01	4.4	2.0	4.8		9.15	4.58	0.93		14.8	0.4	84.8	LS
0.3	0.05	4.9	2.0	4.8		10.18	5.09	0.55		16.8	4.4	78.8	SL
0.3	0.01	3.8	2.3	2.8		7.86	3.93	0.9		12.8	2.4	84.8	LS

Date Rec'd. 9-73
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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal Horizon
Stop #2 Lambeth

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100q	Magnesium Mg meq/100q	Sodium Na meq/100q	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
1707		0-5	7.9	1.3	0.25		4.8	275	6.6	5.0	0.1	0.2	FSL	0
1708		5-10	7.6	0.1	0.5		0.5	275	6.6	7.3	0.1	8.8	L	0
1709		10-14	7.7	0.1	0.25		0.08	188	9.5	8.2	0.1	0.4	L+	0
1710		14-22	8.6	0.1	0.25		0.08	88	+35	18.9	0.1	0.3	L	V-
1711		22-38	8.8	0.1	0.25		0.08	88	+35	19.1	0.1	0.3	L	V-
1712		38-65	8.9	0.1	0.27		0.5	88	21.9	4.3	0.1	0.4	FSL	S+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
								SAR					texture
0.3	0.6	14.1	2.3	8.9		10.31	5.16	0.42		16.8	12.4	70.8	LS
1.4	0.01	8.4	1.6	9.2		13.66	6.83	0.3		22.8	6.4	70.8	SCL
0.7	0.01	5.8	2.0	6.4		16.98	7.99	0.54		26.8	8.4	64.8	SCL
0.3	0.01	4.4	1.8	2.8		20.62	10.31	1.43		34.8	18.4	46.8	SCL
2.8	0.01	3.8	1.8	2.0		14.82	7.41	1.71		24.8	14.4	60.8	SCL
36.6	0.01	3.8	2.0	2.4		5.54	2.77	0.5		8.8	6.4	84.8	LS

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal Horizon
Stop #3 Yawdim

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
1713		0-4	8.3	3.3	0.25		2.2	300	+35	4.1	0.1	0.4	L	M
1714		4-8	8.4	1.8	0.25		0.08	150	+35	4.1	0.1	0.4	L	M+
1715		8-19	8.5	0.8	0.25		0.08	150	+35	4.8	0.1	0.3	FSL	V-

OTHER TESTS REQUIRED SAR

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Texture Others
18.7	0.01	3.9	1.8	2.0		10.55	5.27	1.33		16.8	2.4	80.8	SL
0.7	0.01	3.2	1.8	1.8		9.21	4.61	1.48		14.8	12.4	72.8	SL
4.7	0.15	3.9	1.8	8.6		9.10	4.55	0.3		14.8	10.4	74,8	SL

Ind.-Obs. 2570 5500

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal Horizon
Stop #4 Tullock

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
1716		0-3	8.4	2.0	1.25		1.5	188	9.1	4.6	0.1	0.2	L	LIME 0
1717		3-10	7.7	2.3	0.25		1.1	150	15.5	5.4	0.1	0.4	L	S-
1718		10-22	8.5	0.6	0.25		0.08	150	+35	4.8	0.1	0.3	SL	M+
1719		22-38	8.6	1.7	0.25		0.08	150	+35	7.1	0.1	0.3	FSL	V

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
12.4	0.01	3.9	2.0	5.8		8.08	4.04	SAR 0.33		12.8	2.4	84.8	texture LS
5.5	0.01	4.0	1.8	2.8		11.36	5.68	0.38		18.8	10.4	70.8	SL
0.3	0.01	4.4	1.8	2.4		9.08	4.54	0.9		14.8	0.4	84.8	LS
10.8	0.01	3.9	1.4	2.4		10.36	5.18	0.56		16.8	2.4	80.8	SL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal Horizon
Stop #5 Lambeth

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
1720		0-3	8.4	0.5	0.25		0.08	113	18.5	5.3	0.1	0.3	FSL+	LIME M-
1721		3-7	8.1	0.6	0.25		0.08	275	10.0	8.2	0.1	0.3	L+	0
1722		7-14	8.2	0.5	0.5		0.08	113	+35	10.6	0.1	0.3	L	V-
1723		14-22	8.8	0.1	0.25		0.08	113	+35	14.5	0.1	0.4	L	M+
1724		22-28	8.0	0.1	1.85		0.08	188	34.6	20.8	0.7	0.5	L	V-
1725		28-65	7.5	0.1	0.5		0.08	188	30.7	21.9	3.1	3.2	L+	M-

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	Others
0.7	0.01	3.2	1.4	3.4		7.90	3.95	SAR 0.18		12.8	6.4	80.8	Texture SL
0.7	0.01	5.5	1.6	7.4		13.72	6.86	0.76		22.8	18.4	58.8	SCL
0.3	0.01	2.8	2.2	3.6		16.02	8.01	0.44		26.8	14.4	58.8	SCL
0.3	0.01	3.2	1.8	2.4		15.98	7.99	1.34		26.8	26.4	46.8	SCL
73.7	0.01	3.9	2.0	2.4		12.50	6.25	3.11		20.8	16.4	62.8	SCL
+138	0.01	3.8	1.4	2.8		15.98	7.99	4.92		26.8	22.4	50.8	SCL

Ind.-Obs. 2570 5500

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal Horizon
Stop #6 Yawdim

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
1726		0-5	7.6	2.3	1.85		5.5	275	29.8	7.1	0.1	0.4	L	LIME S+
1727		5-13	7.7	0.3	0.5		9.0	150	+35	10.1	0.1	0.3	SiL	V
1728		13-21	7.3	0.3	0.25		0.08	113	+35	15.7	0.1	0.3	SiL+	V

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
9.1	0.01	3.8	1.4	5.8		11.59	5.79	SAR 0.96		18.8	14.4	66.8	Texture SL
4.7	0.01	3.0	2.0	2.4		18.32	9.16	0.55		30.8	18.4	50.8	SCL
0.3	0.01	3.0	1.4	2.0		17.16	8.58	0.55		28.8	28.4	42.8	CL

Ind.-Obs. 2570 5500

Do Not Write in This Space

Date Rec'd. 9-73
Date Sent

RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal Horizon
Step #7 Ringling

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
1729		0-4	8.1	0.1	0.5		0.08	150	+35	3.4	0.1	0.3	L	M+
1730		4-12	8.1	0.6	0.5		0.5	113	+35	4.3	0.1	0.3	SL	M
1731		12-18	8.2	1.4	0.25		0.08	113	+35	6.2	0.1	0.4	L	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	Others
								SAR					Texture
0.7	0.01	3.9	1.8	6.7		9.02	4.51	0.31		14.8	26.4	58.8	SL
0.3	0.01	4.6	1.8	5.4		6.76	3.38	0.15		10.8	4.4	84.8	LS
27.2	0.15	50.0	2.0	19.4		10.32	5.16	0.4		16.8	4.4	78.8	SL

Ind.-Obs. 2570 5500

Date Rec'd. 2-73
Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal Horizon
Stop #8 Ringling

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100q	Magnesium Mg meq/100q	Sodium Na meq/100q	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
1732		0-3	7.7	5.0	0.5		4.8	413	15.5	9.9	0.1	0.5	SL	0
1733		3-11	8.0	3.8	1.25		4.8	438	+35	9.9	0.1	0.5	L	S

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	Others
													texture
12.9	0.7	14.1	2.3	21.0		3.78	1.89			4.8	48.4	53.2	SL
55.0	0.7	25.5	3.0	28.4		8.75	4.37			13.6	36.8	50.2	L

REPORT C

PROJECT TITLE: OVERBURDEN AND INTERBURDEN ANALYSIS AS RELATED TO REVEGETATION PURPOSES IN COLSTRIP, MONTANA

JUSTIFICATION:

Revegetation can be a problem from soils containing some undesirable characteristics such as high sodium (SAR), high salt, high percentage of clay, structure that causes very little water intake, and low fertility. This analysis and plant growth study was conducted to evaluate the potential problem that may occur from overburden and interburden material during strip mining operations. This was conducted to evaluate the problems that may exist prior to mining operations.

METHODS AND MATERIALS:

Two sets of samples were collected for each mining area by Western Energy Company and taken at 12" increments till in contact with the coal. These samples were composited by depth according to the layers and related to the log that was provided by Western Energy. Not more than 10 feet intervals was composited when layer was near the same throughout. Occasionally, more than 10 feet was taken especially when it was sandy. One set of samples (Area Pit #6 A 10) sent in earlier was taken at 10 foot increments. Analysis and report will be made accordingly.

SAMPLE PREPARATION:

Samples were air dried and split in half by taking alternate 6 inches from each 12" tube. The first half will be kept in the plastic tubes for future use. The second half will be prepared for complete analysis as follows:

Each sample was crushed to 1" by a jaw crusher if necessary. The sample was split after mixing into:

1. 500 grams for weathering and screen analysis if desired.
2. 500 grams screened for mechanical analysis (9 mesh).
3. Screen $<$ 12 mesh and split samples - ½ for green house study
   ½ for laboratory analysis
4. Sample for laboratory analysis was screened to 20 mesh size and kept for analysis. Sample for green house can be used for weathering also if desired. Because large quantities of samples are required for SAR and mechanical analysis, it may be necessary to analyze SAR and use the same sample for mechanical analysis.
5. 100 grams was sent to U.S. Testing Lab for trace elements.
6. Mechanical analysis screen size 9 mesh.

Chemical Analysis

1. pH and conductivity - soil to solution ratio of 1:2.
2. Sodium Adsorption Ratio (qualified by sodium content).
3. Sodium Exchange Potential (calculate if necessary - need CEC also). This has the same interpretation values as SAR.
4. Macro analysis
   Organic Matter
   Nitrate
   Phosphorous
   Potassium
   Calcium
   Magnesium
   Sodium
   Sulfur
5. Micro analysis

Copper

Iron chelatable DTPA extractable

Manganese

Zinc

Aluminum

Barium

Cadmium

Lead

Mercury

Silicon

Strontium

Titanium

Selenium

Floride

Molybdenum

Arsenic

Boron

6. Soluble Salts

7. CEC

8. Mechanical Analysis

9. Water holding capacity at .33 bar and 15 bar suction (method developed by Gordon Decker "Automatic Retreival and Analysis of Soil Characterization Data" PhD Thesis Montana State University, Bozeman, Montana, December 1972.)

10. Plant Growth Test

    a) 500 grams of air dry soil or less if soil not available.

    b) Add 50 ppm P as concentrated super phosphate.

    c) Add 50 ppm N as NH_4NO_3 on weekly basis.

d) Seeded to Winoka winter wheat 6 seed/pot.

e) Water with distilled water to 0.33 Bar or field capacity and maintain weight on daily basis.

f) Harvest - Report dry weight, tillers, and stand.

Results and Discussion

Hole #1 Lab No. 9201-9206

Hole #4 Lab No. 9225-9228

Hole # 5 Lab No. 9229-9285

Hole #6 Lab No. 9286-9297

The chemical and physical analysis for each hole will be discussed separately.

CHEMICAL AND PHYSICAL PROPERTIES

DRILLHOLE # 1

Drill hole #1 contained soft sandstone on the top 27' followed by 26' of coal, 7' of gray shale, then layer of coal, 8' of dark shale, and then the McKay coal.

Although the top 27' was of the soft sandstone, samples were taken and analyzed at ten feet intervals or smaller increments for this strata.

1. pH and Conductivity

   The soft sandstone was analyzed for pH and soluble salts. No unusual pH levels were found in Hole #1.

   The soluble salts were analyzed by mixing 10 grams of soil to 20 ml of deionized water and reading the conductivity of the solution. Salts were found to be present only in the gray shale (53'-63') below the shallow coal layer. Salt level did not exceed 4mmhos/cm and is considered safe.

2. Sodium Adsorption Ratio

   Sodium adsorption ratio is measure of the ratio of sodium, calcium and magnesium in the soil and is used to help predict any physical problems, such as low hydraulic conductivity and low water intake that cause poor plant growth. The soluble sodium and SAR value were very low and anticipate very little effect from sodium in Hole #1.

3. Sodium Exchange Potential

   Not applicable - SAR values very low.

4. Micro Analysis

   Organic matter and nitrate nitrogen are very low. There was no accumulation of nitrate that may affect any aquifer that may develop in future.

5. Phosphorous, Potassium, Calcium, Magnesium and Sulfur

Sodium bicarbonate extractable phosphorous was used for phosphorous analysis. Values below 11 ppm P. Can expect response from the addition of phosphorous fertilizer. Phosphorous appears low in all depths except 10'-20' and 28'-63'. Phosphorous remains an important fertilizer for revegetation potential.

Potassium is considered low in all depths. Definitely require addition of potassium fertilizer.

Sulfur is very high lower in depth and should not be major requirement.

Calcium and magnesium level was not unusually different than normally found in top soil.

5. Micro Analysis

Chelatable DTPA zinc, copper, manganese, and iron were analyzed for Hole #1 as well as boron. These are normally analyzed for predicting plant requirement. There were no unusually high level trace minerals except boron which was slightly higher and may be in the toxic range (4 ppm) for some more sensitive crops in the top sandstone layer. It may be okay for grasses. Other trace elements not complete at present.

6. Soluble Salts

Expressed with pH.

7. Cation Exchange Capacity

Not applicable, SAR values low.

8. Mechanical Analysis

Mechanical analysis is measure ofparticle size distribution by percentage, and provides a guideline for anticipating some physical limitation such as low hydraulic conductivity and low water intake.

The sandstone material is loamy sand texture and should provide good permeability but low water holding capacity. The only depth in question is 63'-68' which is above the coal layer, where there is high percentage of clay and silt (36.8% and 38.4%). This layer should be mixed with some sand and placed at lower depth.

9. Water Holding Capacity

The water holding capacity of loamy sand is very low (approximately 3 %). The top soft sandstone material consists of this texture primarily. The lower depth (dark shale) increases with clay and silt and the water holding capacity also proportionately increases. The lower depths have more desirable texture for water holding capacity, but if clay and silt reamin too high, it will affect the hydraulic conductivity.

10. Plant Growth Test

In progress.

RECOMMENDATIONS

1. The dark shale 63'-68' should be mixed with some sand and placed at lower depth.
2. Should locate boron concentration if present, and be mixed and placed at lower depth.
3. The loamy sand on surface will have good permeability but should mix with loam to improve water holding capacity.

Date Rec'd. 8-13-73
Date Sent

RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59401

FOR: (Grower) Peabody Coal
Core Samples Hole #1

CLIENT: (Dealer)

Lime

Lab No.	Your Field No.	feet Depth ~~(Inches)~~	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	~~Available H2O (Inches)~~
	Box													
9201	1	0-10	8.0	-0.08	9.55		2.5	88	23.6	2.2	0.1	0.3	LS	M
9202	2	10-20	8.0	-0.08	1.85		14.5	150	25.0	2.2	0.1	0 3	LS	M
9203	3	20-30	7.9	-0.08	1.25		7.7	63	19.75	1.55	0.1	0.4	LFS	M-
9204	4	53-58	7.6	1.0	1.25		7.7	113	4.05	3.63	0.1	1.1	L	0
9205		58-63	7.4	1.8	1.25		12.5	63	5.75	5.7	0.1	2.2	L	0
9206	5	63.3- 68.2	7.5	1.0			7.7	150	7.5	5.25	0.1	1.3	L-	0

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
								SAR					Texture
4.7	39.4	5.5	1.6	5.4	4.08	5.54	2.77	0.56		8.8	4.4	86.8	LS
12.4	1.7	7.0	1.4	4.2	2.04	5.54	2.77	0.46		8.8	4.4	85.8	LS
38.8	3.3	11.2	1.0	4.4	1.70	4.38	2.19	0.42		6.8	8.4	84.8	LS
+138	5.0	18.4	4.4	8.9	2.72	14.92	7.46	0.48		24.8	31.5	43.7	L
+138	5.0	61.3	4.0	25.0	3.51	15.02	7.51	0.34		24.8	33.5	41.7	L
	6.9	68.8	3.7	22.8	1.81	21.46	10.73			36.8	38.4	24.8	CL

DRILLHOLE # 4

Drill hole #4 contained brown sandy clay on top 3', 3' of Rosebud smut, 8" of soft coal, 7' of coal, gray shale, 2' of dark shale, 2' of sandstone, and 3' of grey shale and coal

1. pH and Conductivity

   The pH and conductivity is not unusually different. Salt content is low and pH may be slightly acid but it remains in the favorable range.

2. Sodium Adsorption Ratio (SAR)

   SAR values are low and expect no physical problem. Should have good plant growth based on physical properties.

3. Sodium Exchange Potential

   Not applicable.

4. Macro Analysis

   Organic nitrogen is fairly high on the top 3', but this layer has coal seam which increasesthe carbon and increases the organic matter reading.

   Nitrate nitrogen very low and will require supplemental nitrogen.

   Phosphorous, Potassium, Calcium, Magnesium and Sulfur

   Phosphorous is low except in the Rosebud smut. Supplemental phosphorous is very important.

   Potassium is very low and is desirable to add potassium.

   Calcium and magnesium levels are not unusually different than normally found.

   Sulfur may become desirable. It is testing low.

5. Micro Analysis

The micro nutrient extractable EDTA does not show low values and do not expect a response from additional trace minerals.

Boron is testing high in Rosebud smut and the gray shale. It may have some detrimental effect to some crops. These soils should be placed at lower depth.

6. Soluble Salts

See pH and conductivity.

7. CEC

Not applicable.

8. Mechanical Analysis

Texture desirable for water holding capacity and permeability. The low SAR values should make it more desirable.

9. Water Holding Capacity

Sandy clay loams have desirable water holding capacity, and adequate permeability.

10. Plant Growth Test

In progress.

RECOMMENDATIONS

Rosebud smut layer and gray shale immediately above the coal layer should not be used near the surface because of unusually high boron.

Date Rec'd. 8-13-73

Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal

Core Samples Hole #4

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100q	Magnesium Mg meq/100q	Sodium Na meq/100q	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
		feet												LIME
9225	1	0-3	7.0	3.6	3.75		1.0	63	26.3	3.0	0.1	0.4	FSL	M
9226	1	3-6	6.0		2.5		21.2	0	+35	+23	0.3		Coal	S
9227	2	21.2-31.2	6.4	1.9	0.25		0.75	63	8.3	3.1	0.1	1.3	SiL	0
9228	3	31.2-35.6	6.7	1.6	0.5		0.5	25	5.3	4.1	0.1	0.9	L-	0

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
								SAR					Texture
7.4	0.6	7.2	3.6	1.6	1.02	15.22	7.61	0.99		24.8	26.4	48.8	SCL
					4.41			0.34		20.8	16.4	62.8	SCL
+138	5.3	19.0	11.1	3.7	3.62	16.18	8.09	1.19		26.8	16.4	56.8	SCL
	0.8	4.9	1.4	4.4	4.08	9.19	4.59	0.42		14.8	14.4	70.8	SL

DRILLHOLE # 5

Hole # 5 contains brown sandy clay for 19', 16' of brown sandstone, 1' of gray sandstone, 1' of gray shale 26' of coal, 2' of gray shale, and then coal.

1. pH and Conductivity

   The isolated sub-stratographic layer did not contain any unusual level of pH or salt content. Conductivity was well below 4 mmhos/cm which is the desirable level. The brown sandy clay on the surface contained some but not high enough to cause plant injury.

2. Sodium Adsorption Ratio

   Sodium Adsorption Ratio is well below 10. Low hydraulic conductivity will not be influenced by sodium because it is very low.

3. Sodium Exchange Potential

   Not applicable.

4. Macro Analysis

   Organic matter very low except in layer where coal is present. Nitrate nitrogen very low on all depths to coal.

   Supplemental nitrogen becomes very important nutrient and should be added as fertilizer.

   Phosphorous, Calcium, Magnesium, and Sulfur

   Phosphorous and potassium are very low and supplemental fertilizer becomes very important for revegetation potential.

   Calcium and magnesium levels are not unusually different than normally found in the top soil

   Sulfur is very high, especially below in the brown sandstone and gray shale.

5. Micro Analysis

Chelatable DTPA zinc, manganese, copper and iron did not exhibit any unusual levels. They are all considered very high.

Boron is all well below 4 ppm and well above 0.5 ppm B. They are within the desirable level.

6. Soluble Salts

Both the brown sandstone and gray shale above and below the coal contain very little salt.

7. Cation Exchange Capacity

Not applicable

8. Mechanical Analysis

The top brown sand and sandy clay contain near 50 % silt plus clay. Water intake is fairly desirable at this depth. The analysis was not available for the next 16 feet, (19'-35') but is is the brown sandstone shale and should have similar texture as above with possibly less percent clay. These depths appear favorable for top soil material.

The gray shale (35'-40' and 40'-46') contain very high percent clay and silt (greater than 70 %) and was not very desirable for water permeability. This layer, because of very high percentage of fine material, will have low water intake and should not be used as top soil material.

The gray shale below the Rosebud coal contains greater than 75 % clay plus silt and will have slow water intake. This gray shale, however, did not have much salt or sodium as anticipated but because of predicted low hydraulic conductivity, it is unsuitable for top soil material.

9. Water Holding Capacity

The water holding capacity of the brown sandstone was not very high but capable of supporting plant growth. There was adequate clay and silt present to hold moisture for a period of time.

The gray shale contains very high percentage of clay and silt and should exhibit very high water holding capacity.

The gray shale because of fine material present will also be subfected to both wind and water erosion and is very unsuitable for top soil material.

10. Plant Growth Test

In progress. Expect poor growth.

RECOMMENDATIONS

1. Top brown sandy sandstone contains little salt, has desirable permeability, and contains no unusual levels of trace minerals; should be suitable for top soils material.
2. Gray shale should not be used for top soil because of expected low hydraulic conductivity as shown by high percent silt plus clay.

Date Rec'd. 8-13-73

Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal

CLIENT: (Dealer)

Core Samples Hole #5

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100q	Magnesium Mg meq/100q	Sodium Na meq/100q	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
9229	1	0-10	6.8	1.1	0.5		1.5	88	25.0	6.6	0.1	0.4	FSL	M
9230	2	10-20	6.9	0.7	0.25		0.75	2.5	25.0	3.6	0.3	1.5	LFS	M
9278	3	20-25	7.2	0.1	0.25		0.5	63	26.7	10.1	1.1	0.9	L+	M+
9279		25-30	7.3	0.9	0.25		0.5	63	24.5	3.0	0.1	0.8	LFS	M
9280	4	30-35	7.3	0.4	0.25		0.75	2.5	21.9	2.5	0.1	0.7	LFS+	M
9281		35-40	7.2	0.4	0.25		0.5	2.5	16.4	3.0	0.1	1.1	L+	0
9282		40-46	7.1	1.6	0.25		1.0	113	4.9	5.3	0.3	1.1	SiL+	0
9283	6	72-77	7.1	2.6	0.5		2.3	88	5.3	5.3	0.3	1.4	SiL+	0
9284		77-82	7.2	1.7	2.5		0.5	2.5	7.9	5.3	0.3	1.1	SiL+	S-
0285		82-86	7.2	2.9	2.5		0.75	113	15.1	5.9	0.3	1.1	CL-	S+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
								SAR					Texture
6.9	0.8	4.9	4.4	1.4	0.57	23.05	11.53	0.43		38.8	12.4	48.8	SC
+138	1.6	4.6	2.0	3.4		9.02	4.51	0.56		26.8	22.4	50.8	SCL
+138	1.6	4.6	2.0	3.4	0.57			1.33					
+138	6.0	9.3	3.8	7.6				0.68					
102	3.2	8.0	3.6	5.4	1.81	14.86	7.43	0.73		24.8	16.4	58.8	SCL
+138	3.5	14.8	3.6	6.2	2.94	36.9	18.45	0.76		62.8	14.4	22.8	C
+138	5.6	26.0	3.7	4.8	1.81	26.58	13.29	1.04		44.8	36.4	18.8	C
+138	5.2	25.5	3.6	6.4	1.02	23.22	11.61	1.1		38.8	36.4	24.8	CL
+138	47.5	3.2	2.5	15.0	1.59	19.74	9.87	1.23		32.8	46.4	20.8	CL
+138	4.0	26.0	3.8	14.4	2.04	17.46	8.73	2.13		28.8	52.4	18.8	SiCL

DRILLHOLE # 6

Hole # 6 contains 4' of top soil, 9' of brown damp clay, 4' of brown sandy clay, 3' of gray sandy clay, 3' of brown sandstone, 9' of soft gray sandstone, 27' of coal, dark shale with coal, 2' of gray shale, 8' of gray sandstone, 10' of gray shale, and coal.

1. pH and Conductivity

The top soil, as well as the soil below, does not exhibit any unusual pH level. The top soil, brown clay, and sandy clay all contained salt that can restrict plant growth and production. These soils are not suitable for top soil.

The soil below all contained salt but at lower concentration. The presence of some salts, however, and high sulfate sulfur indicate that the soil may show some white spots as the soil is removed and stockpiled.

2. Sodium Adsorption Ratio

The SAR values did not exceed 10, but the second depth (5'-10') contained sodium that approached SAR 10value and indicates that a potential problem exists and this soil should be mixed and placed at lower depth.

3. Sodium Exchange Potential

Not applicable.

4. Macro Analysis

Organic matter is present on the top 5 feet which is desirable but the salt content makes it unsuitable for top soil potential. Nitrogen is very low and suggest use of nitrogen to aid seedling establishment, and maintain growth and production.

Phosphorous is very low especially as soil is mixed with lower depth. Potassium is very low also if soil is mixed with lower depth.

These soils in general contain calcium and magnesium at levels normally found in most soils. The magnesium and sodium is correspondingly higher at 5'-10' depth and is related to the salt level also.

5. Micro Analysis

Chelatable DTPA zinc, manganese, copper and iron all exhibit adequate level with no toxic levels. However, at 73'-78' the boron was very high and may be toxic to some crops that are planned to be used for revegetation purpose. This should be evaluated in the greenhouse.

The other trace minerals were not complete at this time on all holes. The trace minerals are aluminum, barium, cadmium, fluoride, lead, mercury, silicon, selenium, molybdenum, arsenic, strontium, and titanium. These should be done hopefully within a few days.

6. Soluble Salts

See pH and Conductivity.

7. CEC

Not applicable.

8. Mechanical Analysis

Particle size distribution below the Rosebud coal contains high percentage of fine materials which makes it less desirable for top soil material.

The gray shale above the McKay also exhibited some very fine salt particles and is not suitable for top soil because of expected low water intake.

The brown sandstone located deeper (20') seems to be a more desirable top soil material than the top soil present because of low salt, sodium, and with desirable texture for water intake. The water holding capacity is very low however, but a micture of some loam will make it more suitable.

9, Water Holding Capacity

Gray shale above the coal seam exhibited high moisture holding capacity because of the high clay content. This should be mixed and buried at lower depth.

10. Plant Growth Test

In progress.

RECOMMENDATION

1. The top soil, brown damp clay, brown sandy clay (0-15') contain high level of salt mixed with sodium and are not suitable for topsoil.
2. The brown sandy clay and gray sandy clay show signs of salt also but not high enough to cause any seedling emergence problems. These depths are more sandy than recorded and seem more appropriate for top soil if need to be substitited.
3. Boron was very high (+22 ppm B) in the gray shale (73'-78') above the coal and may be toxic to some crops. It is not suitable for top soil and should be mixed and placed at lower depth.

Date Rec'd. 8-13-73
Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Peabody Coal
Core Samples Hole #6

CLIENT: (Dealer)

Lime

Lab No.	Your Field No.	Feet Depth ~~(Inches)~~	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100q	Magnesium Mg meq/100q	Sodium Na meq/100q	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
9286	1	0-5	6.9	3.5	1.25		0.5	188	+35.0	13.3	1.0	4.6	SiL+	M
9287		5-10	6.9	0.6	0.5		3.5	150	+35.0	+23.0	4.4	5.8	SiCL+	M
9288		10-15	7.3	0.1	0.25		0.75	63	34.1	10.0	1.3	3.3	FSL+	M
9289		15-20	8.0	0.2	2.5		0.5	2.5	30.7	5.9	0.3	1.0	FSL	M+
9290	3	20-25	7.9	0.6	2.5		0.75	0	24.5	3.6	0.1	1.0	VFSL-	M
9291		25-30	7.9	0.2	5.55		0.5	0	20.6	2.7	0.3	1.1	LFS	M
9292	4	30-32	7.6	0.7	1.25		-0.5	2.5	2.0	2.5	0.3	1.2	LFS	O
9293	5	58.9-63.9	7.4	2.3	6.25		0.75	63	3.3	4.1	0.	1.3	L	O
9294		63.9-68.9	7.6	1.3	5.55		0.5	63	9.1	2.5	0.3	0.9	VFSL	S
9295	6	68.9-7319	7.6	1.5	0.25		0.75	63	25.5	2.2	0.3	1.0	L+	M
9296		73.9-78.9	7.7	1.4	0.25		-0.5	113	20.3	3.6	0.3	1.2	L+	M
9297	7	78.9-80.5	7.7	2.3	0.25		0.5	63	15.1	5.9	0.3	1.1	SiCL-	S

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
								SAR					Texture
+138	0.8	3.8	2.2	3.4	1.81	4.74	2.37	3.39		6.8	52.4	40.8	SiL
+138	1.2	4.4	6.4	3.6	1.81	4.44	2.22	8.40		6.8	70.4	22.8	Sil
+138	0.5	3.9	2.3	2.0	0.57	6.70	3.35	3.14		10.8	4.4	84.8	LS
+138	0.5	4.0	2.2	2.8	0.57	11.34	5.67	2.10		18.8	2.4	78.8	SL
+138	0.3	2.6	2.0	3.6	1.02	6.76	3.38	1.49		10.8	4.4	84.8	LS
+138	2.9	4.0	2.2	4.4	1.70	6.70	3.35	1.23		10.8	52.4	36.8	SiL
+138	4.1	4.6	2.0	2.8	0.34	6.76	3.38	1.28		10.8	50.4	38.8	Sil
+138	2.8	12.2	3.6	5.8	1.25	15.08	7.54	0.94		24.8	46.4	28.8	L
+138	1.9	20.6	2.0	7.4	0.46	10.46	5.23	1.10		16.8	44.4	38.8	L
+138	0.9	50.0	2.6	14.8	2.04	16.14	8.07	1.35		26.8	38.4	34.8	L
+138	1.3	61.3	18.0	3.2	+22.62	18.44	9.22	1.18		30.8	50.4	18.8	SiCL
+138	3.2	61.3	21.4	4.0	0.68	34.62	17.31	1.21		58.5	12.4	29.1	C

Ind.-Obs. 2570 5500

APPENDIX #5

PRELIMINARY HYDROLOGY INVESTIGATION

Research
Conducted by Richard L. Hodder
Research Associate
Montana Agricultural Experiment Station
Bozeman, Montana

Cooperating with
Peabody Coal Company

Summer, 1970

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Summer, 1970

The objectives of this study are to determine both short and long term effects of strip mining on surface water quality and storage, stream flow, and ground water.

The procedural plan calls for designing and installing a practical system of monitoring surface water stream flow in a mined drainage and in a similar, but undisturbed control drainage. Data from these monitoring systems are to be accumulated over a period of years. The intent is to establish a historical flow pattern and to record the changes in this pattern as mining progresses. The effects of accumulating acres of mine spoils are expected to substantially influence surface flow.

Ground water fluctuations are to be recorded by maintaining a series of wells within the mined drainage both upstream and downstream from the pit area. Water level within wells is to be measured and recorded monthly to provide continuous data on the rise and fall of the water levels and how it is influenced and affected by mining.

In late 1969, monitoring devices were obtained consisting of weight operated clock mechanisms driving a chart-covered drum on which a stylus records the rate of waterflow as it passes through a calibrated "V"-notched weir. Two weirs were fabricated of 3/16" reinforced steel plates in Bozeman and were shipped to the study site. One was assembled and installed in the mined drainage and the other assembled and installed in the control drainage of approximately equal size and of similar vegetative cover and condition. Stilling wells were installed with the monitoring systems mounted on top.

Monitoring of the rate of flow from these two drainage areas started in March of 1970 following completion of the installations. This date preceded any significant amount of snow melt and surface water flow.

Continuous monitoring showed that there was no measurable amount of spring flow from melting snow and early spring rains during the first season. However, flow was monitored from the mined drainage when the expanding pit area intercepted the monitored drainage area and pumping from this portion of the pit began. The intercepted surface water and accumulated ground water was measured as it flowed through the weir. Waters intercepted by or accumulated in other segments of the pit were diked off from this study area and were diverted through another drainage that circumvents the weir.

Calibration of the weirs is not complete because sufficient water flow has not yet occurred to make this job possible, but the duration and flow pattern is recorded for later interpretation following calibration.

The depth to ground water was measured each month in two locations where "wet" borings indicated the presence of ground water. Two wells were drilled and cased; one was located downstream from the pit area in the vicinity of the mined drainage weir, and the other was located in the same drainage upstream from the pit. The well upstream from the pit served its purpose until late November, when a change of mining plans caused its interception and destruction.

Table 1 consists of readings on the presence of surface flow, depth to ground water and associated precipitation.

The unexpected change of mining plans resulting in the destruction of the ground water measuring well above the original pit location emphasizes several shortcomings in design of the present hydrologic study. A series of observation wells was originally planned but because the drilling rig was not in the vicinity, additional wells were not drilled. In the very near future, ten additional holes will be cased to enlarge the piezometer study in the drainage area above the pit. These will be spaced at approximately 150 feet intervals up the drainage from the present highwall. Additional holes downstream from the pit are planned; it is

Table 1. Surface flow, precipitation, and depth to ground water measured monthly in 1970 at Peabody Big Sky Mine site, Colstrip, Montana.

Dates	Surface Flow		Monthly ppt. in inches	Depth to Ground Water in Feet	
	Control Area	Mined Area		Upstream from pit	Downstream from pit
Apr-May	0	0	(No guage)	(No Well)	(No Well)
May-June	0	0	2.20	29.4	30.3
June-July	0	19 days flow	1.60	----	----
July-Aug	0	17 days flow	1.00	35.9	31.5
Aug-Sept	0	0	.84	38.4	31.9
Sept-Oct	0	0	.70	39.0	30.5
Oct-Nov	0	0	.67	(destroyed well)	31.6
Nov-Dec	0	0	----	----	----
		Total	7.01		

hoped that the Peabody Coal Company will graciously drill both series for the study. The direct costs to the project are for purchasing casing necessary for these wells and installing it at the appropriate time.

Several additional observation wells located within the control drainage are considered necessary as a check on the general water levels in the area. These are desirable in order to determine to what extent below the pit the effects of mining upstream influence ground water levels downstream.

Casual observations show great contrast in ground water flow exposed in various segments of the highwall adjacent to the study area. These have not been measured or recorded. These observations point out the need for similar studies under varied conditions and uses, for the diverting of large quantities of intercepted ground water may be critical if it is a source of supply depended upon for domestic, commercial, or community use. Either loss of quantity or quality of water could be economically catastrophic to nearby ranches or communities.

APPENDIX #6

MAJOR PLANT COMMUNITIES AND TAXA
OF
AREA A
PEABODY COAL COMPANY

By

Ecological Consulting Service

WILDLIFE CONDITIONS

An analytical assessment of the ecological relationships of the native fauna and flora of the Big Sky Mine was initiated in early July, 1973. The study area was composed of 10 sections: 13 through 15, 21 through 24, and 26 through 28 of Township 1 North, Range 41 East, in Rosebud County, Montana. Field work began with a concentrated study of Area A with primary emphasis on wildlife reconnaissance and quantitative vegetation measurements. The results of these studies are reported herein.

Natural Vegetation

Area A of the Big Sky Mine lies within the Eastern Ponderosa Pine Forest vegetation formation, as described by Küchler (1964). An orientation survey of the area indicated the presence of seven natural vegetation types and three agricultural vegetation types. Map B shows the juxtaposition of the vegetation types on the ten sections of the study area. Each vegetation type was assigned a code number which corresponds to the following description.

Quantitative measurement of the low growth natural vegetation was accomplished by use of a modified "Daubenmire" transect method (Daubenmire, 1959). A 2x5 decimeter frame was placed at 5-foot intervals along a 100-foot line. The frequency of plant taxa falling within the frame, as well as the

TABLE II

PARAMETERS OF THE OVERSTORY VEGETATION IN ONE TIMBER TRANSECT ON AREA A OF THE PEABODY BIG SKY COAL MINE, COLSTRIP, MONTANA

TAXA	RELATIVE DENSITY*	RELATIVE FREQUENCY	RELATIVE DOMINANCE	AVERAGE DBH	AVERAGE HEIGHT	TOTAL BASAL AREA
Juniperus scopulorum	28%	64%	6%	2.63 in.	10.75 ft.	110.28 in.^2
Pinus ponderosa	72%	100%	94%	7.03 in.	27.94 ft.	1823.86 in.^2

Mean Distance: 14.43 ft.

Mean Area Occupied by an Individual: 208.22 ft.^2

Density (Number of Individuals Per Acre): 209.20 Trees Per Acre

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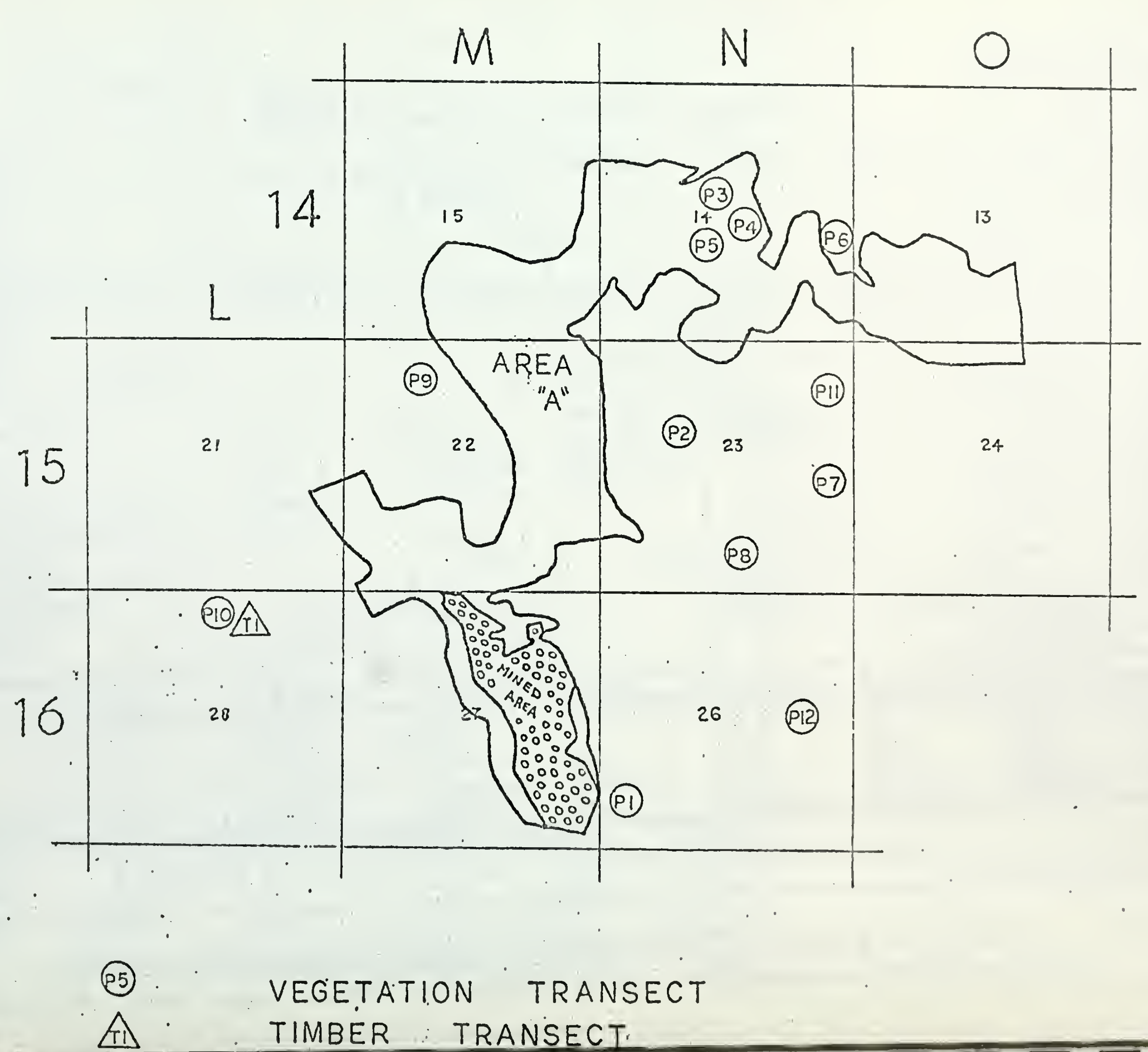
*Formulas for compilation of data come from Phillips (1959). Transect location appears on Map C.


M
N
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14
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28
27
26
AREA "A"
MINED AREA
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
T1
P5 VEGETATION TRANSECT
T1 TIMBER TRANSECT

CONSTANCY, PERCENT CANOPY COVERAGE AND FREQUENCY OF LOW-GROWING TAXA FOR VEGETATION TYPES AS DETERMINED BY EXAMINATION OF TWENTY 2x5 DECIMETER PLOTS ON EACH OF TWELVE SITES

EASTERN PONDEROSA PINE FORMATION

TAXA	Big Sagebrush-Grassland Type (1) (Code 101) 2 Sites	Silver Sagebrush-Grassland Type (Code 102) 2 Sites	Rhus-Grassland Type (Code 201) 1 Site	Ponderosa Pine Type (Code 301) 2 Sites	P. Pine-Juniper Type (Code 302) 1 Site	Caprock Gumbo Knob Type (Code 303) 1 Site	Creek Bottom Type (Code 401) 3 Sites
GRASSES AND GRASS-LIKE PLANTS:							
Agropyron smithii	(2) 100/ 6/85	100/22/100				100/10/80	33/15/33
Agropyron spicatum	50/13/35	50/ 8/ 8		100/11/75	100/23/95	100/12/55	
Agropyron trachycaulum				50/Tr/ 3			67/ 9/42
Andropogon scoparius				50/ 1/ 5			
Aristida longiseta		50/Tr(3)/ 3					
Bouteloua curtipendula				50/ 5/13			
Bouteloua gracilis	100/ 4/50	100/ 7/38	100/ 2/25				
Bromus japonicus		50/ 3/33	100/ 1/35				33/ 1/ 2
Bromus tectorum		100/35/98	100/ 8/70	100/Tr/10			67/ 4/35
Calomovilfa longifolia			100/ 2/10	100/ 3/20			33/ 2/ 3
Carex viridula							33/Tr/3
Carex spp.			100/11/70	50/ 1/18			
Elymus canadensis							67/ 5/18
Hordeum jubatum							33/ 7/27
Koeleria cristata	100/17/93	100/11/80	100/ 2/25	100/Tr/ 5	100/ 4/55		
Oryzopsis micrantha							33/ 1/ 3
Panicum virgatum							33/ 3/ 7
Poa pratensis							100/29/45
Poa scabrella		50/ 8/15					
Poa secunda	100/ 3/ 9	100/ 4/53	100/Tr/ 5	50/Tr/ 5	100/ 1/35		
Spartina gracilis							67/12/20
Stipa comata	50/ 4/47	100/10/58	100/25/80	100/ 5/10			
Stipa viridula	50/ 2/ 8						67/ 8/25

(Continued)

T A X A	Big Sagebrush-Grassland Type (Code 101)	Silver Sagebrush-Grassland Type (Code 102)	Rhus-Grassland Type (Code 201)	Ponderosa Pine Type (Code 301)	P. Pine-Juniper Type (Code 302)	Caprock Gumbo Knob Type (Code 303)	Creek Bottom Type (Code 401
	2 Sites	2 Sites	1 Site	2 Sites	1 Site	1 Site	3 Sites
FORBS:							
Achillea millefolium				50/ 2/20	100/ 1/35		33/Tr/12
Antennaria rosea				50/Tr/ 3	100/Tr/ 5		
Arenaria hookeri				50/Tr/ 5	100/ 1/10		
Artemisia frigida	50/ 1/28	100/ 3/38		50/Tr/ 3	100/Tr/15		33/Tr/ 2
Artemisia ludoviciana				50/ 2/13	100/Tr/15		33/Tr/ 5
Astragulus dasyglottis				50/Tr/10			
Astragulus gilviflorus						100/ 3/45	
Astragulus gracilis			100/Tr/ 5				
Astragulus missouriensis					100/ 2/20		
Astragulus purshii	50/Tr/ 3						
Astragulus striatus				50/Tr/ 5	100/ 1/ 5		
Cerastium arvense				50/ 1/ 8	100/ 2/65		
Chenopodium album							33/ 4/10
Chrysopsis villosa				50/ 1/ 5			
Echinaceae pallida				50/Tr/ 8			
Eriogonum annum			100/Tr/ 5				
Eriogonum multiceps					100/Tr/10	100/Tr/10	
Erigeron divergens	50/ 1/18						
Erigeron pumilus	50/Tr/ 3						
Eurotia lanata	50/Tr/ 3						
Gaura coccinea		100/ 1/13		100/Tr/ 8	100/ 3/30		33/Tr/ 2
Glycyrrhiza lepidota				50/ 1/ 3			
Grindelia squarrosa		50/Tr/ 5				100/ 1/15	67/ 1/10
Haplopappus nuttalli						100/Tr/10	
Haplopappus spinulosus			100/ 2/35				
Hedeoma drummondii		50/Tr/ 8	100/Tr/ 5				33/Tr/ 3
Helianthus annuus							33/Tr/ 2
Lepidium densiflorum	50/Tr/ 3						
Linum perenne			100/Tr/ 5	50/Tr/ 3	100/Tr/20		
Lithospermum arvense							
Lygodesmia juncea			100/Tr/ 5				

(Continued)

T A X A	Big Sagebrush-Grassland Type (Code 101)	Silver Sagebrush-Grassland Type (Code 102)	Rhus-Grassland Type (Code 201)	Ponderosa Pine Type (Code 301)	P. Pine-Juniper Type (Code 302)	Caprock Gumbo Knob Type (Code 303)	Creek Bottom Type (Code 401
	2 Sites	2 Sites	1 Site	2 Sites	1 Site	1 Site	3 Sites
Forbs (Continued):							
Mamillaria vivipara				50/Tr/ 3			
Medicago lupulina							67/ 7/32
Medicago sativa							33/10/23
Melilotus officinalis							67/ 4/18
Oenothera caespitosa						100/ 1/40	
Oenothera serrulata				50/Tr/ 3			
Opuntia polycantha	50/Tr/ 3	50/Tr/ 3					
Oxytropis lambertii					100/ 3/25		
Petalostemon candidum			100/Tr/ 5	50/ 1/10			
Phlox hoodii	100/ 1/35	50/ 1/ 5			100/ 5/60	100/ 1/15	
Plantago purshii	50/Tr/ 8	50/Tr/13	100/Tr/25				33/Tr/ 2
Potentilla gracilis				50/Tr/ 3	100/ 1/ 5		
Psoralea argophylla	50/ 1/ 1	50/Tr/ 5	100/Tr/ 5				
Senecio canus				50/Tr/ 3			
Solidago missouriensis				50/Tr/ 3			67/ 1/15
Solidago mollis					100/ 3/45	100/Tr/ 5	
Sphaeralcea coccinea		100/ 1/30					
Taraxacum officinale	50/Tr/ 5	100/ 1/15		100/Tr/ 5			33/Tr/10
Thermopsis rhombifolia					100/ 5/60	100/Tr/10	
Tragopogon dubius	100/ 4/38	100/ 5/60					67/Tr/ 8
Vicia americana				50/Tr/ 3		100/ 1/15	
Yucca glauca			100/ 4/10	50/ 2/ 3			
Unknown Forb X	50/Tr/ 3	50/ 7/43	100/12/95				33/ 2/12
SHRUBS:							
Artemisia biennis			100/ 6/35				
Artemisia cana		50/ 5/15			100/Tr/ 5		33/10/27
Artemisia dracunculus				50/Tr/3			
Artemisia tridentata	100/28/68				100/ 3/15		
Chrysothamnus nauseosus						100/ 4/45	

(Continued)

T A X A	Big Sagebrush-Grassland Type (Code 101)	Silver Sagebrush-Grassland Type (Code 102)	Rhus-Grassland Type (Code 201)	Ponderosa Pine Type (Code 301)	P. Pine-Juniper Type (Code 302)	Caprock Gumbo Knob Type (Code 303)	Creek Bottom Type (Code 4
	2 Sites	2 Sites	1 Site	2 Sites	1 Site	1 Site	3 Sites
Shrubs (Continued):							
Gutierrezia sarothrae	100/14/55	100/ 5/30	100/ 6/30	50/Tr/ 5	100/ 2/30	100/ 1/25	33/Tr/
Juniperus scopulorum				50/ 1/ 3	100/ 5/35		
Rhus trilobata			100/19/25	50/ 2/ 3	100/ 3/15		33/ 1/
Ribes aureum					100/Tr/ 5		
Rosa arkansana					100/ 1/15		67/ 1/
Symphoricarpos occidentalis							33/ 6/1

---

(1) Vegetation code names correspond with vegetation map.
(2) Constancy (% occurrence among sites)/canopy coverage (% of area covered)/average frequency (% occurrence among plots).
(3) Tr = trace; a value less than .5%.
(4) Trees under 4½ feet in height were quantitatively measured as shrubs.

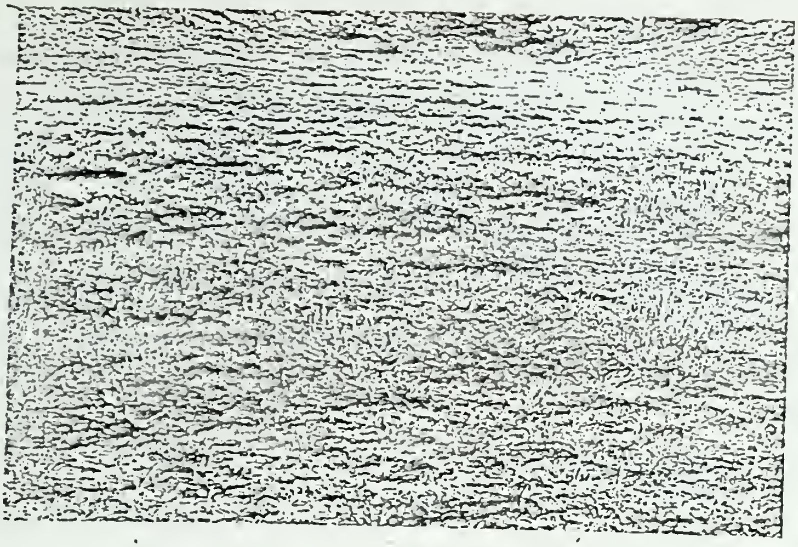

Figure 1. Big Sagebrush-Grassland Vegetation Type (Code 101) showing the dominant aspect of big sagebrush (*Artemesia tridentata*).

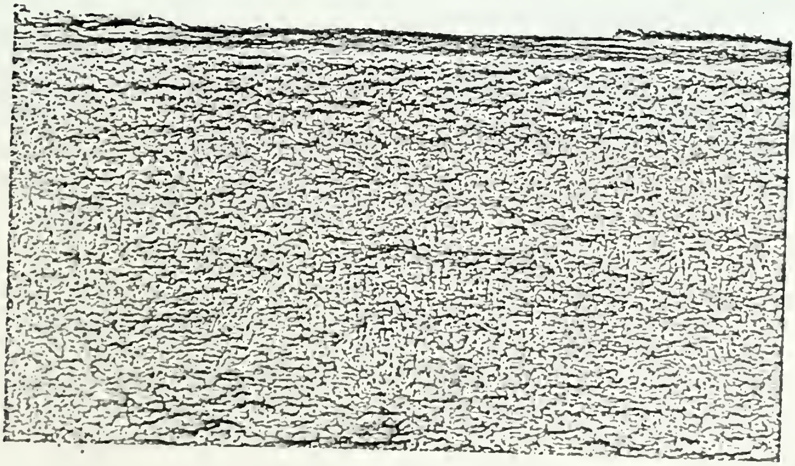

Figure 2. Silver Sagebrush-Grassland Vegetation Type (Code 102) showing the dominant aspect of silver sagebrush (*Artemesia cana*).

canopy coverage and constancy of each species, was recorded at each site. Each site was located entirely within a distinctly recognizable plant community. The coverage classes used to estimate the canopy coverage of each species were: Class 1, 0-1%; Class 2, 2-5%; Class 3, 6-25%; Class 4, 26-50%; Class 5, 51-75%; Class 6, 76-95%; and Class 7, 96-100%. The midpoints of each coverage class were used in data compilation and tabulation. A total of 12 "Daubenmire" transects were established on the study area.

Additionally, the study of one transect was conducted to quantitatively measure the overstory vegetation and characterize the dendrological characteristics. The quarter method described by Phillips (1959), was used to sample the tree stands. The "timber" transect consisted of 12 sites approximately 30 paces apart, in which one tree was measured in each quarter of a circle. Each tree was measured for diameter at breast height (DBH), distance from site center, and estimated height. Two additional trees were measured at a thirteenth site to complete a total of 50 trees per transect. Data was compiled by using the formulas described by Phillips (1959).

To ascertain the percentage of the study area occupied by each vegetation type, an acetate overlay the size of one section of land, and scaled the same as the vegetation map, was uniformly gridded with 100 dots and super-imposed on the vegetation map over each of the ten sections of the study area. The vegetation type underlying each dot was recorded until a total of 1000 dot-points had been sampled. The aggregate percentage of dot-points overlying each vegetation type indicated the percentage of the area composed of each vegetation type.

Plant taxa of the area were identified with the aid of the floral keys of Booth (1950) and Booth and Wright (1959). A list of the plant taxa in the vicinity of Area A, identified to date, appears in the accompanying Table. This list is only partially complete at this time, and has not yet been compared with a herbarium collection for verification.

Further vegetation sampling at the Big Sky Mine site is planned in the near future. A brief narrative description of each vegetation type follows:

Big Sagebrush-Grassland Vegetation Type (Code 101)

This vegetation type occurred typically on the lower elevation benches, flats, and steep footslopes, and appeared to be closely associated with the soils of the Ringling and Lambeth series, as described by Parker (1970). This vegetation community occupied 7% of the study area, as determined by the dot-grid overlay technique. A diversity index value of 38.24 and 55.00 (Odum 1959; and Phillips, 1959) for the two transects in this vegetation type would suggest that the Big Sagebrush-Grassland Type is a relatively mature and stable plant community. This type was characterized by big sagebrush (*Artemisia tridentata*) and broom snakeweed (*Gutierrezia sarothrae*) dominating the shrub aspect of the landscape (Figure 1). The dominant grasses appeared to be western wheatgrass (*Agropyron smithii*), junegrass (*Koeleria cristata*), blue grama (*Bouteloua gracilis*), and sandberg bluegrass (*Poa secunda*). A variety of annual and perennial forbs occurred on this type.

Silver Sagebrush-Grassland Vegetation Type (Code 102)

This vegetation type occurred, typically, on the lower elevation benches and flats, just as did the Big Sagebrush Vegetation Type (Figure 2). It also appeared to be closely associated with the soils of the Ringling and Lambeth series. Silver sagebrush tends to occupy moister sites than big sagebrush. A diversity index value of 37.89 and 47.85 for the two transects in this floral community indicate that it is a relatively stable and mature plant community. This vegetation type was the most prevalent, and occupied 30.7% of the study area. Silver sagebrush (*Artemisia cana*) and broom snakeweed are the prevailing shrubs. Western wheatgrass, junegrass, cheatgrass (*Bromus tectorum*), and needle-and-thread (*Stipa comata*) are the most predominant grasses. Fringed sagewort (*Artemisia frigida*) and common salsify (*Tragopogon dubius*) were the prevalent forbs.

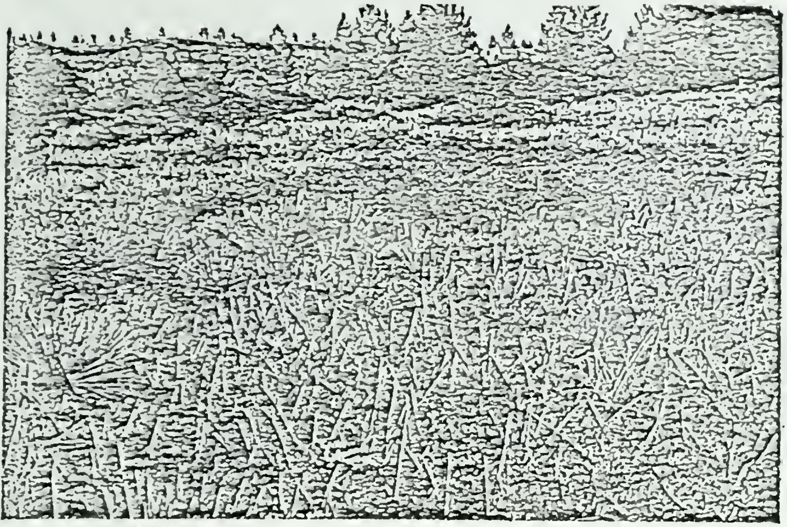

Figure 3. Rhus-Grassland Vegetation Type (Code 201) as found on the sandy footslopes.

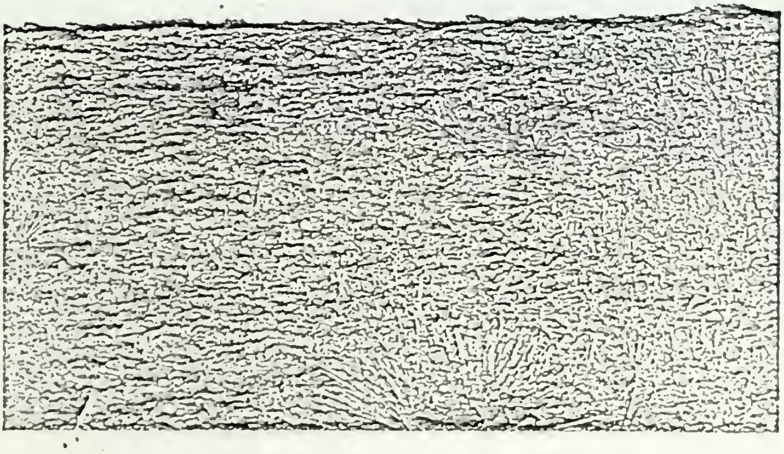

Figure 4. Rhus-Grassland Vegetation Type (Code 201) as it occurs on a sparsely "shrubby" site.

Rhus-Grassland Vegetation Type (Code 201)

This vegetation type generally occurred on the sandy footslopes beneath sandstone outcroppings (Figure 3) on soils of the Lambeth series, where it seemed to function as a transitional zone, or ecotone, between the upland timber vegetation types and the lower elevation grasslands. This type was quite variable, with an admixture of plant species from several other vegetation types. The aspect of this vegetation community varied from conspicuously "shrubby" to a near paucity of shrubs (Figure 4). This type also occurred on the Ringling soils of the upland mesas (Figure 5). A diversity index of 28.04 is probably indicative of a transitional zone, and indicates the rather variable community. Rhus-Grassland was the second most common vegetation type, occupying 19.2% of Area A. Skunkbush sumac *(Rhus trilobata)*, biennial sagewort *(Artemisia biennis)*, and broom snakeweed were the most common shrubs found in this type. Needle-and-thread, cheatgrass, and sedges *(Carex* spp.*)* were the predominant grasses or grass-like plants of the type. Spiny goldenweed *(Haplopappus spinulosus)* and woolly plantain (*Plantago purshii)* were the most commonly occurring known forb plants.

Ponderosa Pine Vegetation Type (Code 301)

The Ponderosa Pine Vegetation Type typically occurred on the slopes and ridges dominated by Yawdim and Lambeth

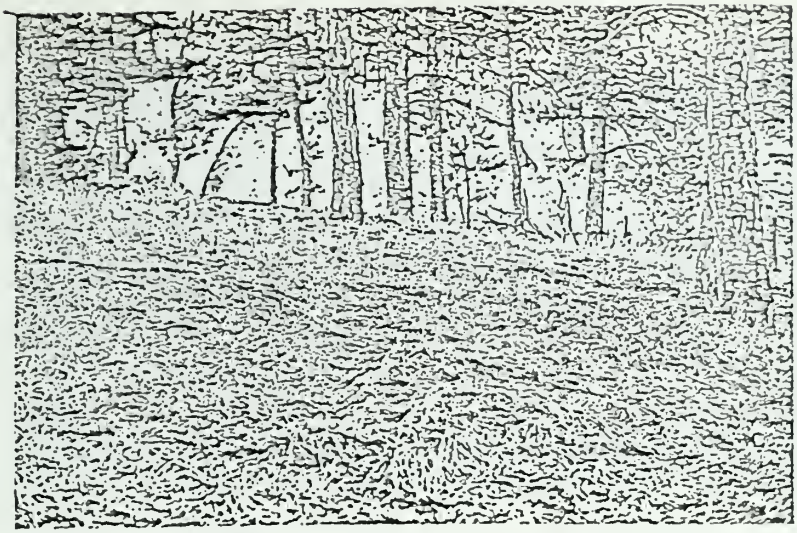

Figure 7. Ponderosa Pine Vegetation Type (Code 301) showing the understory aspect.

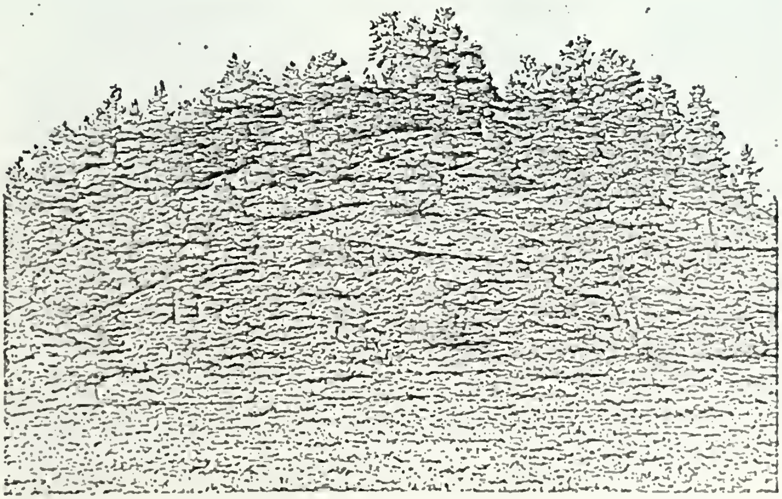

Figure 8. The Ponderosa Pine-Juniper Vegetation Type (Code 302) on an east slope.

soils (Figure 6). Extended "fingers" of this type often followed the moist bottoms in the very upper extremities of creek drainages. The overstory aspect of this type varied from a near closed canopy woods to an open canopy park of scattered trees. This type appeared to exhibit, most conspicuously, the effect of favorable soil and moisture conditions. The understory vegetation of this type varied inversely with the overhead canopy in regard to cover. In areas of open canopy, the understory vegetation complex was well developed, and cover values were "normal" for the overall area. In areas of closed canopy, the understory was sparse and poorly developed, as might be expected (Figure 7). Diversity index values of 13.20 and 15.00 for the two "Daubenmire" transects in this type substantiated this developmental concept. The Ponderosa Pine Vegetation Type occupied 16.4% of the area. The principle shrubs of the understory were broom snakeweed and skunkbush sumac. The representative grasses of this type were bluebunch wheatgrass *(Agropyron spicatum)* and prairie sand reedgrass *(Calomovilfa longifolia)*. The characteristic forbs present were white prairie clover *(Petalostemon candidum)*, scarlet gaura *(Gaura coccinea)*, and field chickweed *(Cerastium arvense)*.

Ponderosa Pine-Juniper Vegetation Type (Code 302)

This vegetation type primarily occurred on the mesic north and east slopes of the coarse and rocky Yawdim soils (Figure 8). On the drier south and west slopes, the actual

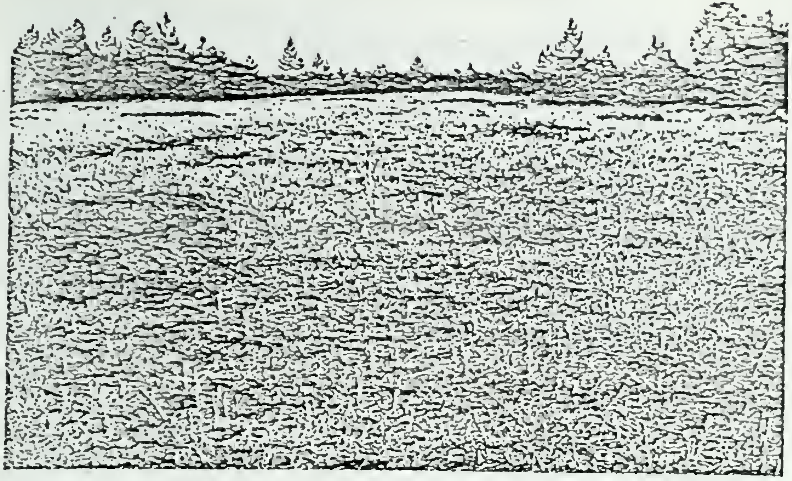

Figure 5. The Rhus-Grassland Vegetation Type (Code 201) on an upland mesa.

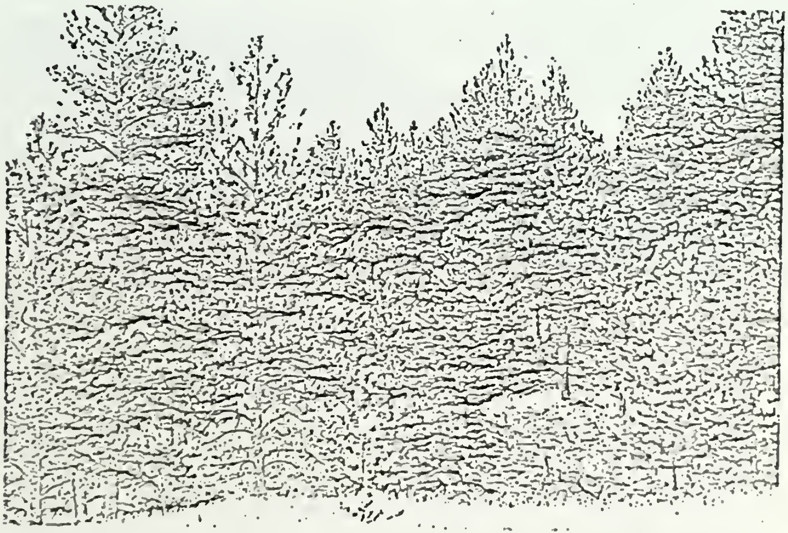

Figure 6. Ponderosa Pine Vegetation Type (Code 301) showing the overstory aspect.

timber aspect was often sparse (Figure 9), but the soil conditions were consistent with this type, and these situations may represent a "preclimax" (Oosting 1956) of the Ponderosa Pine-Juniper Vegetation Type. This type often intergraded freely to the Ponderosa Pine Vegetation Type. This type comprised 13.1% of the study area. One "timber" transect was run in the Ponderosa Pine-Juniper Vegetation Type. A diversity index of 82.00 for the overstory vegetation suggests that this "timber" community is reasonably stable. The understory vegetation of this vegetation type was variable, as the diversity index of 27.69 for the one "Daubenmire" transect indicates. The major woody vegetation species present in the understory of this community were broom snakeweed and young Rocky Mountain juniper *(Juniperus scopulorum)*. The predominant grasses represented in this floral community were bluebunch wheatgrass and junegrass. A wide variety of forbs occurred in this type.

Caprock-Gumbo Knob Vegetation Type (Code 303)

This type comprised only .1% of the study area and, where present, occurred on the Yawdim soils as described by Parker (1970). This type was found on extremely severe sites with steep slopes and possibly localized alkaline conditions (Figure 10). A relatively low diversity index of 28.46 implies that this type is a "subclimax" or "preclimax" (Oosting, 1956), probably of one of the timber vegetation types. The most prevalent shrubs on this type

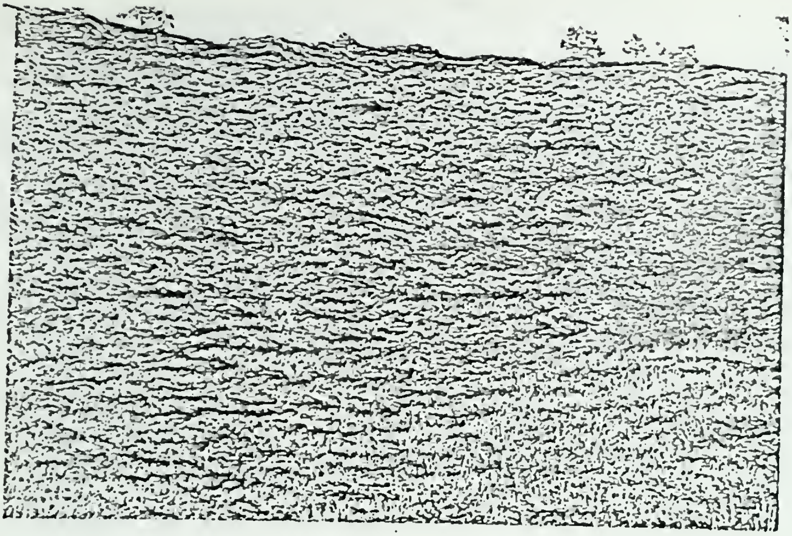

Figure 9. The Ponderosa Pine-Juniper Vegetation Type (Code 302) at a dry west slope site.

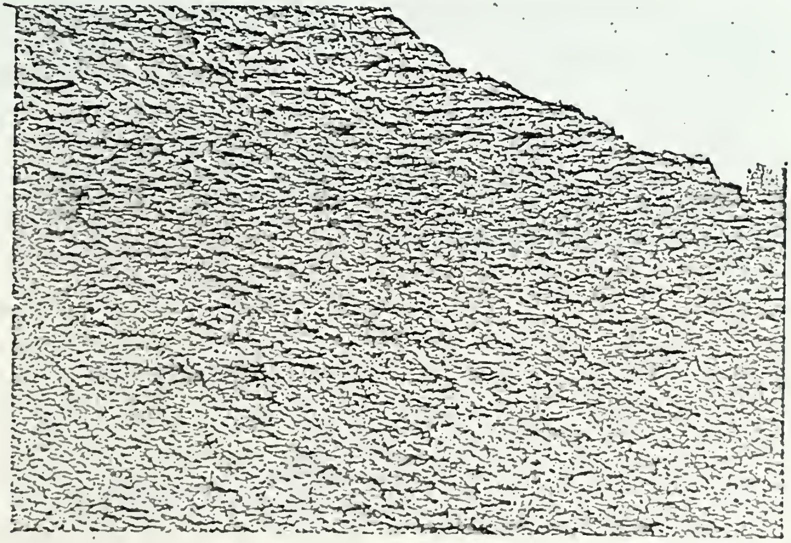

Figure 10. Caprock-Gumbo Knob Vegetation Type (Code 303). Note the paucity of ground cover.

were rubber rabbitbrush *(Chrysothamnus nauseosus)* and broom snakeweed. The primary grasses found here were western wheatgrass and bluebunch wheatgrass. Characteristic forbs included threeleaved milkvetch *(Astragalus gilviflorus)*, *(Eriogonum multiceps)*, tufted evening primrose *(Oenothera caespitosa)*, and prairie thermopsis *(Thermopsis rhombifolia)*. Ground cover on this type was extremely sparse.

Creek Bottom Vegetation Type (Code 401)

The Creek Bottom Vegetation Type typically occurs on the alluvial soils of the drainage bottoms and comprises 4.3% of the study area. This type was quite variable and may have been in a perpetual state of "disclimax" due to frequent disturbance by flooding. Diversity indices on this vegetation type were inconsistent and may have been the result of the progressive change and disturbance along the course of the drainage. In the upper reaches of the drainages, this type appeared as a mesic swale containing dense stands of silver sagebrush, prairie rose *(Rosa arkansana)*, and western snowberry *(Symphoricarpos occidentalis)* (Figure 11). Progressing down the drainage, boxelder *(Acer negundo)*, and plains cottonwood *(Populus deltoides)* assume a dominant overstory aspect, and the silver sagebrush, prairie rose, and western snowberry remain the characteristic understory vegetation (Figure 12). Grasses uniquely characteristic to the Creek Bottom

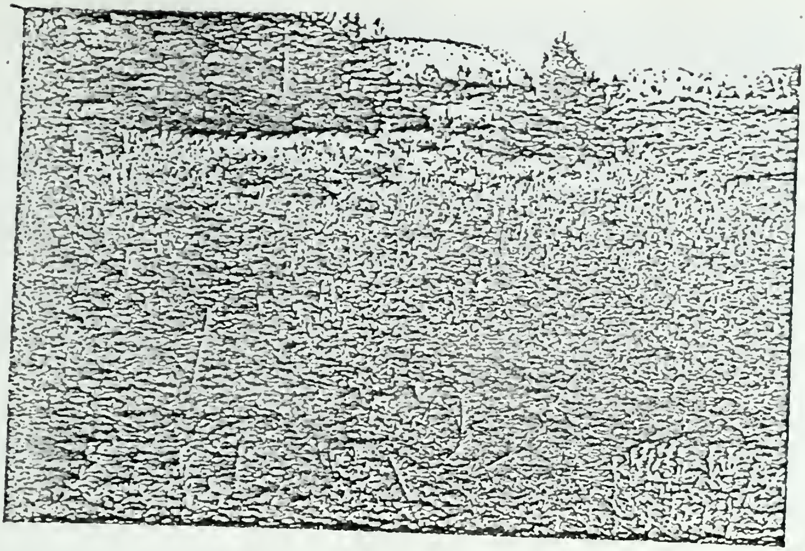

Figure 11. Mesic swale aspect of the Creek Bottom Vegetation Type (Code 401).

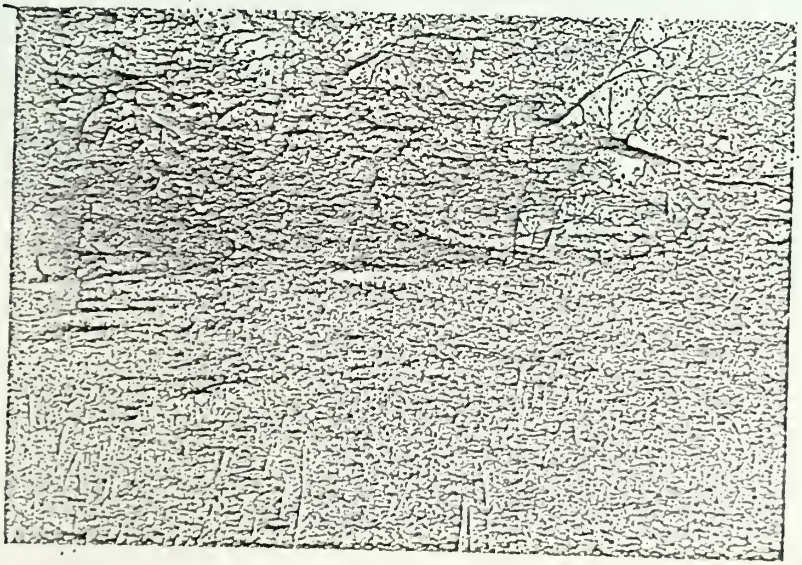

Figure 12. Creek Bottom Vegetation Type (Code 401) with a plains cottonwood *(Populus deltoides)* overstory.

Vegetation Type were Canada wild-rye (*Elymus canadensis*), foxtail barley (*Hordeim jubatum*), switchgrass (*Panicum virgatum*), Kentucky bluegrass (*Poa pratensis*), and alkali cordgrass (*Spartina gracilis*). Cudweed sagewort (*Artemisia lucoviciana*), black medic (*Medicago lupulina*), and *Solidago missouriensis* were common forbs of the Creek Bottom Vegetation Type.

Agricultural Vegetation Types

The distribution of the Agricultural Vegetation Types, Abandoned Meadow (Code 501); Hayfield (Code 502); Grainfield (Code 503), bore little relation to the natural physiognamy of the area. Hayfields (Figure 13) often were found on the floodplain of the major creek bottoms of the area, or wherever agricultural practices, such as irrigation and row cropping, could support hay crops. Dry farming grain crops (Figure 14) could be found in nearly any locale where the topography of the area did not prohibit use of farm machinery. The Abandoned Meadow Type (Figure 15) occurred wherever former hay or grain cropland was left dormant and allowed to return to natural vegetation. Various stages of secondary succession could be found in this vegetation type. No quantitative sampling was conducted on any of the agricultural vegetation types due to their homogeneity and temporary nature. The Abandoned Meadow Vegetation Type made up .3% of the

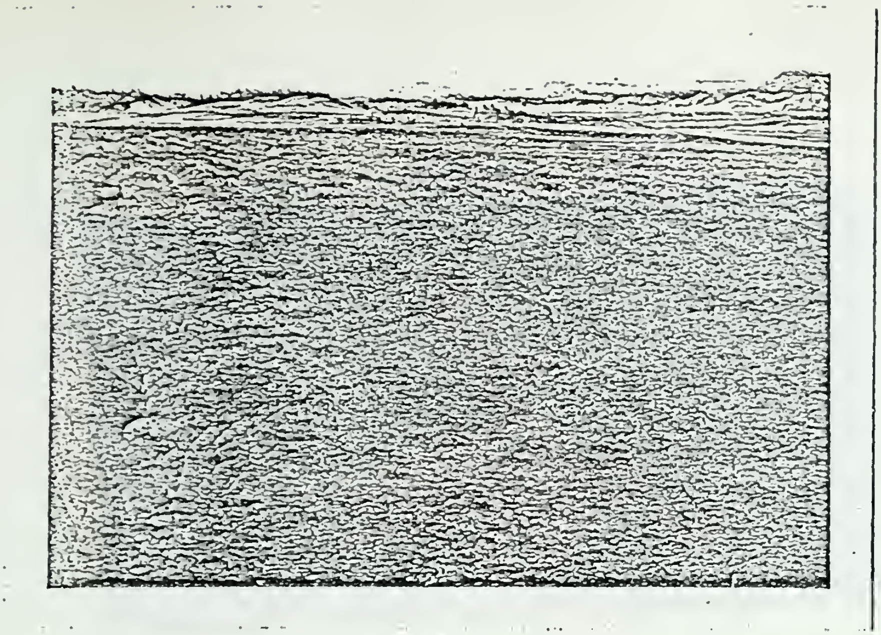

Figure 13. Hayfield Vegetation Type (Code 502). Notice dry land row cropping.

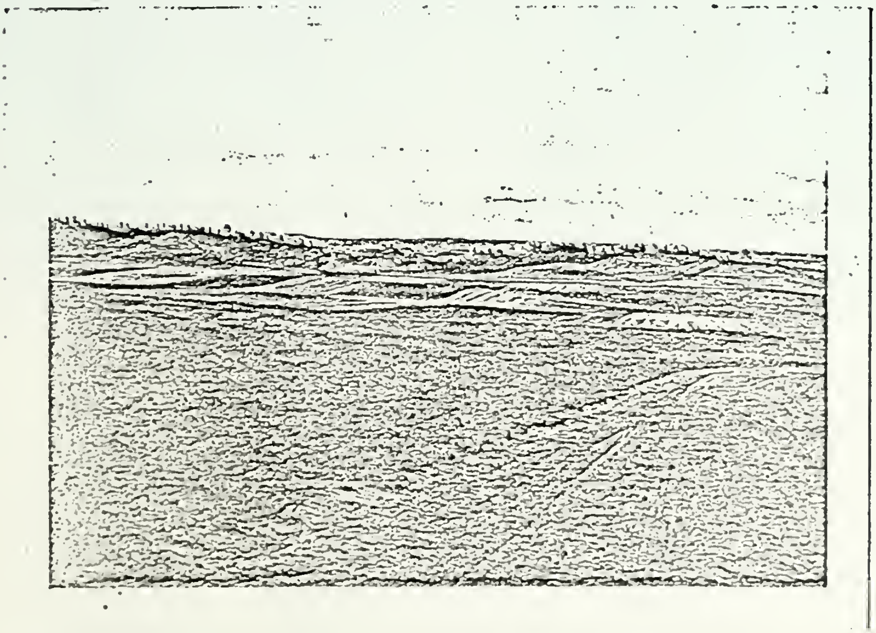

Figure 14. Grain Field Vegetation Type (Code 503). Notice strip planted grain fields and summer fallow.

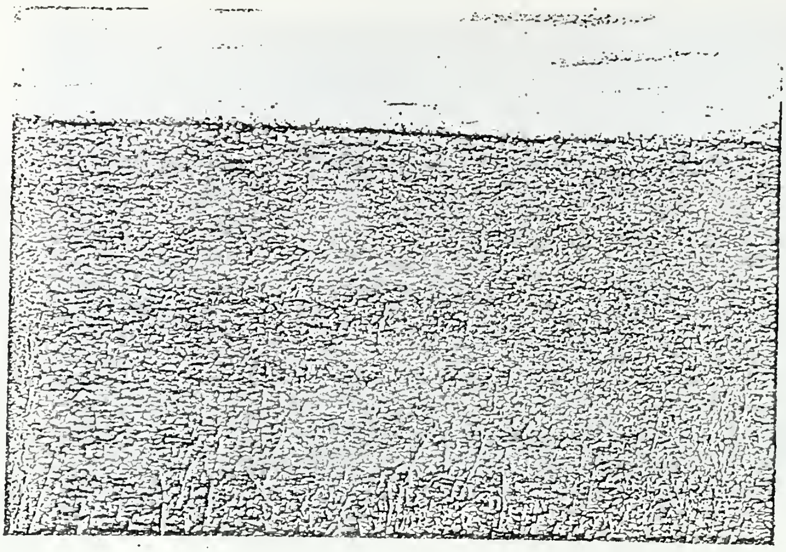

Figure 15. The Abandoned Meadow Vegetation Type (Code 501).

area; the Hayfield Type, 19%; and the Grain Cropland type, 4.7%.

Peabody Coal Mine Site

The vegetation complex of the coal mine spoils bank is unique, with varying degrees of natural revegetation and reclamation. The spoils banks vegetation was not studied during the field study period covered in this report. The coal mine site occupied 3.3% of the study area.

PARTIAL PLANT LIST OF THE COLSTRIP VICINITY*

	Scientific Name	Common Name
TREES:	*Acer negundo*	Boxelder
	Fraxinus pennsylvanica	Green ash
	Juniperus scopulorum	Rocky Mountain juniper
	Pinus ponderosa	Ponderosa Pine
	Populus deltoides	Plains cottonwood
	Salix spp.	Willow
	Ulmus americana	American elm
SHRUBS:	*Artemisia cana*	Silver sagebrush
	Artemisia tridentata	Big sagebrush
	Atriplex confertifolia	Shadscale saltbush
	Atriplex nuttallii	Nuttall saltbush
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Chrysothamnus viscidiflorus	Green rabbitbrush
	Crataegus succulenta	Fleshy hawthorn
	Eurotia lanata	Winterfat
	Gutierrezia sarothrae	Broom snakeweed
	Juniperus horizontalis	Creeping juniper
	Oenothera serrulata	Shrubby evening primrose
	Prunus americana	Wild plum
	Prunus virginiana	Chokecherry
	Rhus trilobata	Skunkbush sumac
	Ribes aureum	Golden currant
	Ribes cereum	Squaw currant
	Ribes setosum	Redshoot gooseberry
	Rosa arkansana	Prairie rose
	Shepherdia argentea	Buffalo-berry
	Symphoricarpos occidentalis	Western snowberry
GRASSES AND GRASS-LIKE PLANTS:	*Agropyron desertorum*	Crested wheatgrass
	Agropyron smithii	Bluestem
	Agropyron spicatum	Bluebunch wheatgrass
	Agropyron trachycaulum	Slender wheatgrass
	Andropogon geradi	Big bluestem
	Andropogon scoparius	Little bluestem
	Aristida longiseta	Red three-awn
	Bouteloua curtipendula	Side-oats grama
	Bouteloua gracilis	Blue grama
	Bromus inermis	Smooth brome
	Bromus japonicus	Japanese chess
	Bromus tectorum	Downy chess brome

(Continued)

	Scientific Name	Common Name
Grasses and Grass-like plants (Continued):	*Calamovilfa longifolia*	Prairie sand reedgrass
	Carex spp.	
	Carex viridula	Green sedge
	Elymus canadensis	Canada wild-rye
	Festuca octoflora	Six-week fescue
	Hordeum jubatum	Foxtail barley
	Koeleria cristata	Junegrass
	Muhlenbergia cuspidata	Plains muhly
	Oryzopsis hymenoides	Indian ricegrass
	Oryzopsis micrantha	Littleseed ricegrass
	Panicum virgatum	Switchgrass
	Phalaris arundinacea	Reed canary grass
	Poa ampla	Big bluegrass
	Poa canbyi	Canby bluegrass
	Poa pratensis	Kentucky bluegrass
	Poa scabrella	Pine bluegrass
	Poa secunda	Sandberg bluegrass
	Scirpus spp.	
	Spartina gracilis	Alkali cordgrass
	Sporobolus airoides	Alkali dropseed
	Stipa comata	Needle-and-thread
	Stipa viridula	Green needlegrass
	Typha latifolia	Common cattail
FORBS:	*Achillea millefolium*	Yarrow
	Allium textile	Wild onion
	Alisum plantago-aquatica	American water-plantain
	Alyssum alyssoides	Pale alyssum
	Amaranthus albus	White pigweed
	Amaranthus retroflexus	Redroot pigweed
	Androsace septentrionalis	Northern androsace
	Antennaria parvifolia	Small-leaf pussytoes
	Antennaria rosea	Rose pussytoes
	Argemone intermedia	Prickly poppy
	Arenaria hookeri	Hooker sandwort
	Artemisia biennis	Biennial sagewort
	Artemisia dracunculus	False-tarragon sagewort
	Artemisia frigida	Fringed sagewort
	Artemisia ludoviciana	Cudweed sagewort
	Asclepias speciosa	Showy milkweed
	Asclepias verticillata	
	Asclepias viridiflora	Green milkweed
	Aster canescens	Hoary aster
	Astragalus canadensis	Canada milkvetch
	Astragalus cicer	Cicer milkvetch
	Astragalus dasyglottis	Purple milkvetch
	Astragalus gilviflorus	Three-leaved milkvetch
	Astragalus gracilis	

(Continued)

	Scientific Name	Common Name
Forbs (Continued):	*Astragalus missouriensis*	Missouri milkvetch
	Astragalus purshii	Pursh loco
	Astragalus striatus	Prairie milkvetch
	Bahia oppositifolia	Opposite-leaf bahia
	Balsamorhiza Sagittata	Arrowleaf balsamroot
	Besseya wyomingensis	Kittentail
	Calochortus nuttallii	Mariposa lily
	Camelina microcarpa	Littlepod false-flax
	Campanula rotundifolia	Roundleaf harebell
	Capsella bursa-pastoris	Shepherd's purse
	Carduus nutans	Musk thistle
	Castilleja sessiliflora	Indian paintbrush
	Crepis spp.	Hawksbeard
	Cerastium arvense	Field chickweed
	Chaenactis douglasii	Douglas dusty maiden
	Chenopodium album	Lamb's quarter
	Chenopodium leptophyllum	Narrowleaf goosefoot
	Chorispora tenella	
	Chrysopsis villosa	Golden-aster
	Cirsium undulatum	Wavyleaf thistle
	Comandra umbellata	Pale bastard toadflax
	Convolvulus arvensis	Field bindweed
	Cryptantha bradburiana	Miner's candle
	Delphinium bicolor	Low larkspur
	Draba nemorosa	Woods draba
	Echinaceae pallida	Purple coneflower
	Erigeron divergens	Spreading fleabane
	Erigeron pumilus	
	Eriogonum annum	Annual eriogonum
	Eriogonum multiceps	
	Erodium cicutarium	Alfilaria
	Erysimum asperum	Plains wallflower
	Euphorbia robusta	Robust spurge
	Evolvulus nuttallianus	
	Fritillaria pudica	Yellow bell
	Gaura coccinea	Scarlet gaura
	Gaura parviflora	Small-flowered gaura
	Geum triflorum	Prairie smoke
	Gilia congesta	Densely flowered gilia
	Glycyrrhiza lepidota	Wild licorice
	Grindelia squarrosa	Curlcap gumweed
	Hackelia floribunda	Many flowered stickseed
	Haplopappus lanceolatus	Lance goldenweed
	Haplopappus nuttallii	Nuttall goldenweed
	Hedeoma drummondii	Drummond false pennyroyal
	Helianthus annuus	Common sunflower
	Helianthus petiolaris	Prairie sunflower
	Hymenopappus filifolius	Narrowleaf hymenopappus
	Kochia scoparia	Kochia, summer cypress
	Lactuca pulchella	Blue lettuce
	Lactuca serriola	
	Lappula echniata	European stick tight

(Continued)

	Scientific Name	Common Name
Forbs (Continued):	*Lappula redowskii*	Western stick tight
	Lepidium densiflorum	Prairie pepperweed
	Lepidium perfoliatum	Clasping pepperweed
	Lesquerella ludoviciana	Silver bladderpod
	Leucocrinum montanum	Mountain star lily
	Liatris punctata	Dotted blazingstar
	Linum perenne	Blue flax
	Linum rigidum	Stiffstem flax
	Lithospermum arvense	Field gromwell
	Lithospermum incisum	Narrowleaf gromwell
	Lomatium spp.	
	Lupinus lepidus	Pacific lupine
	Lygodesmia juncea	Rush skeleton weed
	Mamillaria vivipara	Pink pincushion cactus
	Marrubium vulgare	Horehound
	Medicago lupulina	Black medic
	Medicago sativa	Alfalfa
	Melilotus alba	White sweetclover
	Melilotus officinalis	Yellow sweetclover
	Mentha arvensis	Field mint
	Mentzelia decapetala	Ten-petal blazing star
	Mertensia lanceolata	Lanceleaf bluebell
	Microseris cuspidata	
	Monarda fistulosa	Horse mint
	Oenothera biennis	Rydberg's evening primrose
	Oenothera caespitosa	Tufted evening primrose
	Oenothera nuttallii	Nuttall evening primrose
	Opuntia polycantha	Plains pricklypear
	Oxytropis lambertii	Purple pointloco
	Oxytropis sericea	White pointloco
	Pedicularis paysoniana	
	Penstemon albidus	White penstemon
	Penstemon eriantherus	Fuzzytongue penstemon
	Penstemon nitidus	Waxleaf penstemon
	Petalostemon candidum	White prairie-clover
	Petalostemon purpureum	Purple prairie-clover
	Phacelia franklinii	
	Phacelia hastata	Silverleaf phacelia
	Phlox hoodii	Hoods phlox
	Phlox kelseyi	Kelsey phlox
	Physaria didymocarpa	Common twinpod
	Plantago purshii	Woolly plantain
	Potentilla gracilis	Northwest cinquefoil
	Psoralea argophylla	Silverleaf scurfpea
	Psoralea esculenta	Breadroot scurfpea
	Psoralea tenuiflora	Slimflower scurfpea
	Ranunculus glaberrimus	Sagebrush buttercup
	Ratibida columnifera	Prairie coneflower

(Continued)

	Scientific Name	Common Name
Forbs (Continued):	*Rhus radicans*	Poison ivy
	Rumex crispus	Curl dock
	Sagittaria cuneata	Arum-leaved arrowleaf
	Salsola kali	Russian thistle
	Senecio canus	Woolly groundsel
	Sisymbrium altissimum	Tumblemustard
	Sisymbrium loeselii	Smallpod tumblemustard
	Smilacina stellata	Starry false Solomon's seal
	Solidago missouriensis	
	Solidago mollis	Goldenrod
	Sphaeralcea coccinea	Scarlet globemallow
	Taraxacum officinale	Common dandelion
	Thermopsis rhombifolia	Prairie thermopsis
	Thlaspi arvense	Fanweed
	Townsendia hookeri	
	Tradescantia occidentalis	Spiderwort
	Tragopogon dubius	Common salsify
	Urtica dioica	Stinging nettle
	Verbascum thapsus	Flannel mullein
	Verbena bracteata	Bracted verbena
	Vicia americana	American vetch
	Viola nuttallii	Nuttall violet
	Yucca glauca	Soap-weed
	Zigadenus venenosus	Meadow death camas

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*This list is not complete at this time. Plant specimens were identified in the field with the aid of floral keys. Specimens have not been verified by comparison with a herbarium collection.

APPENDIX #7

WILDLIFE INVESTIGATIONS

By

Ecological Consulting Service

WILDLIFE CONDITIONS

An analytical assessment of the ecological relationships of the native fauna and flora of the Big Sky Mine was initiated in early July, 1973. The study area was composed of 10 sections: 13 through 15, 21 through 24, and 26 through 28 of Township 1 North, Range 41 East, in Rosebud County, Montana. Field work began with a concentrated study of Area A with primary emphasis on wildlife reconnaissance and quantitative measurements. The results of these studies are reported herein.

Birds:

A vehicle observation route has been established on the study area, and records are being maintained for all faunal species observed since the inception of the study. Non-game birds observed while traveling this route are merely listed to indicate presence. Game bird observations are documented as to location to the nearest 1/10th mile by latilong designation coordinates, time of day, species, age, sex, flock composition, weather, animal activity, and vegetation type on which the birds occurred.

A list of all game and non-game birds observed on Area A or the surrounding vicinity appears in the accompanying Table. No game birds have been observed on Area A at the time of this report; however, several game species of waterfowl are known to utilize the area during the spring and fall migration. There are large and well established populations of sharp-tailed grouse in the immediate area, and a few sage grouse have been observed. The major creek bottoms of nearby areas are known to harbor pheasant populations of various numbers, and a few Hungarian partridge are known to be close by. Wildlife reconnaissance is continuing on the area.

Animals

Mammal and reptile presence on Area A was recorded in the same manner as avian observations. Game mammal observations were fully recorded and documented, and non-game mammals and reptiles were recorded as to presence.

The mammals and reptiles observed in the proximity of the study area to date are listed in the accompanying Table. Only one observation of pronghorn antelope *(Antilocapra americana)* has been recorded on the area at the time of this writing; however, pronghorns are quite common in this vicinity. Several observations of mule deer *(Odocoileus hemionus)* have been made on Area A. Thirty-seven individual mule deer sitings were made, with most of the occurring on the Rhus-Grassland Vegetation Type. Observation routes are planned to continue throughout the field period of this study.

Small mammal trap lines have been placed in four locations within various vegetation types in an attempt to ascertain species present and "relative" abundance. Each trap line consisted of ten snap-type Victor mouse traps baited with peanut butter, placed approximately 30 paces apart, and located entirely within a distinctly recognizable plant community. The trap line is checked and baited daily for a trapping period of five days at each trap line site. The species of small mammal trapped, the Trap

Station Number (1-10), sex, age, and breeding condition of animals trapped is recorded. No attempt has been made to investigate the "absolute" numbers of these small mammal populations. The results of this trapping appear in the accompanying Table. It is too early in the data gathering process to draw any conclusions from the trap line results at this time. Small mammal trapping will continue for the duration of the study.

Insects

No evaluation of the insect populations of the Big Sky Mine vicinity have been made at this time.

Endangered Species

Only two animals from the rare and endangered species list, the black-footed ferret *(Mustela nigripes)* and the American peregrine falcon *(Falco peregrinus anatum)*, could be expected to be found on the prairies of the eastern Montana region. No sign of either species has been found on the Peabody Big Sky Mine Area A to date.

Aquatic

No evaluation of the aquatic habitats or the limnological characteristics of the aquatic environs of the area have been made at this phase of the study. However, some work of this nature is planned for the near future.

SMALL MAMMAL SPECIES TRAPPED AT FOUR TRAP LINE SITES IN AREA A OF THE PEABODY BIG SKY COAL MINE, COLSTRIP, MONTANA

TRAP LINE #1* -- (N. 016.8) BIG SAGEBRUSH-GRASSLAND TYPE

No small mammals were trapped at this trapping site.

TRAP LINE #2 -- (N. 316.4) SILVER SAGEBRUSH-GRASSLAND TYPE

Species	July 12	July 13	July 14	July 15	July 16	Total
Western Deer Mouse *(Peromyscus maniculatus)*	0	0	0	1	0	1

TRAP LINE #3 -- (N. 514.5) PONDEROSA PINE VEGETATION TYPE

Species	July 25	July 26	July 27	July 28	July 29	Total
Western Deer Mouse *(Peromyscus maniculatus)*	0	0	0	1	0	1

TRAP LINE #4 -- (N. 614.5) RHUS-GRASSLAND TYPE

Species	July 25	July 26	July 27	July 28	July 29	Total
Western Deer Mouse *(Peromyscus maniculatus)*	3	4	1	1	3	12
Prairie vole *(Microtus ochrogaster)*	0	0	0	1	0	1

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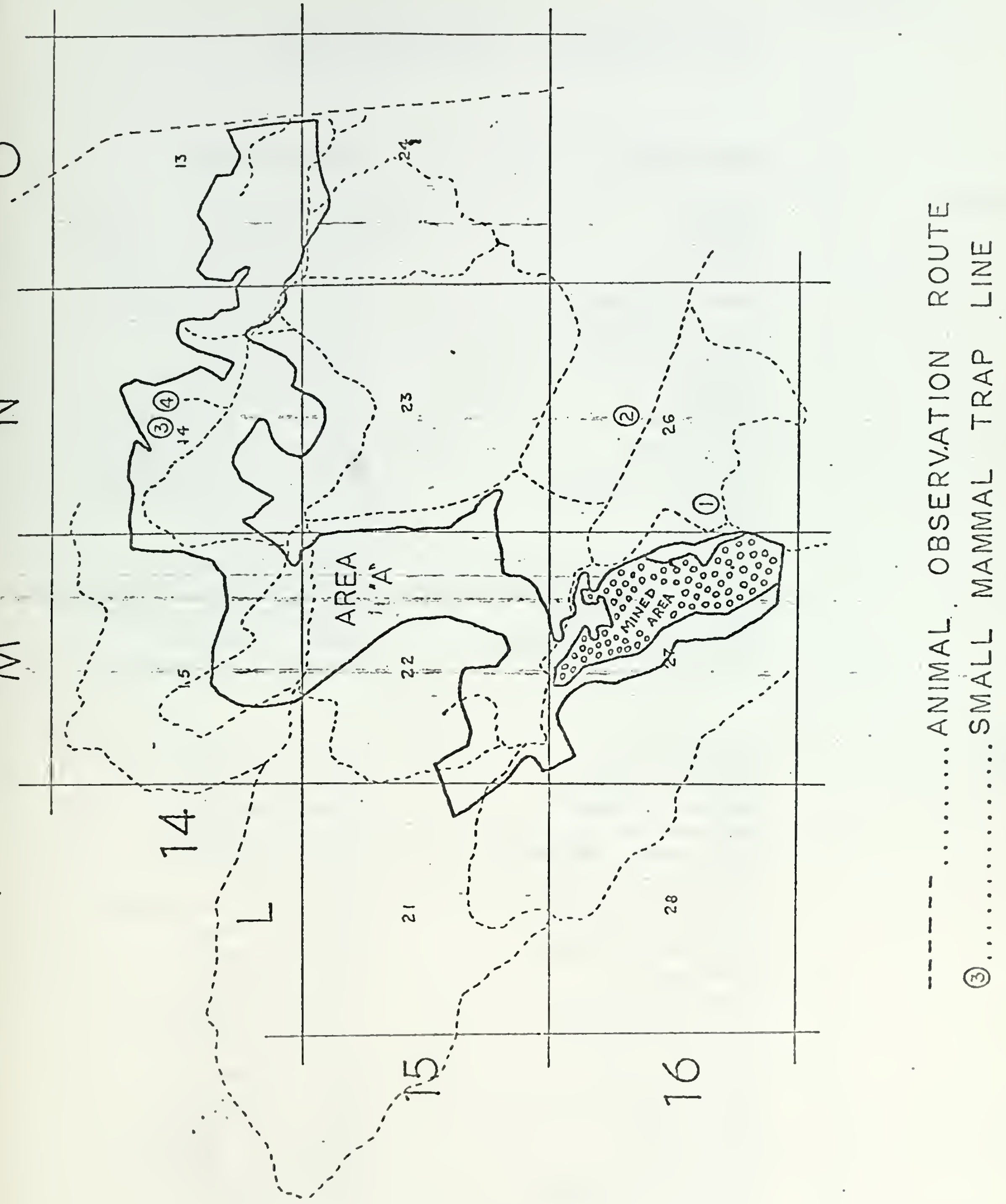
*Trap line locations are shown on the accompanying Map.

LOCATION OF FOUR SMALL MAMMAL TRAP LINE SITES AND ANIMAL OBSERVATION ROUTES ON MINING AREA A OF THE PEABODY BIG SKY COAL MINE, COLSTRIP, MONTANA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- - - - ....ANIMAL OBSERVATION ROUTE
③..........SMALL MAMMAL TRAP LINE

LIST OF ANIMALS OBSERVED ON AREA A OF THE PEABODY BIG SKY COAL MINE OR ON THE IMMEDIATE SURROUNDING VICINITY

	Common Name	Scientific Name
MAMMALS:	Badger	*Taxidea taxus*
	Bobcat	*Lynx rufus*
	Coyote	*Canis latrans*
	Deer Mouse	*Peromyscus maniculatus*
	Desert cottontail	*Sylvilagus audubonni*
	Least chipmunk	*Eutamias minimus*
	Longtail weasel	*Mustela frenata*
	Mule deer	*Odocoileus hemionus*
	Muskrat	*Ondatra zibethicus*
	Porcupine	*Erethizon dorsatum*
	Prairie dog	*Cynomys lucovicianus*
	Prairie vole	*Microtus ochrogaster*
	Pronghorn antelope	*Antilocapra americana*
	Raccoon	*Procyon lotor*
	Red fox	*Vulpes vulpes*
	Striped skunk	*Mephitus mephitus*
	Thirteen-lined ground squirrel	*Spermophillus tridecelineatus*
	White-tailed deer	*Odocoileus virginianus*
	White-tailed jackrabbit	*Lepus townsendii*
	Yellowbelly marmot	*Marmota flaviventris*
BIRDS:	American coot	*Fulica americana*
	American goldfinch	*Spinus tristis*
	American widgeon	*Mareca americana*
	Barn swallow	*Hirundo rustica*
	Black-capped chickadee	*Parus atricapillus*
	Blue-winged teal	*Anas discors*
	Brewer's blackbird	*Euphagus cyanocephalus*
	Brewer's sparrow	*Spizella breweri*
	Brown-headed cowbird	*Molothrus ater*
	Cinnamon teal	*Anas cyanoptera*
	Common crow	*Corvus brachyrhynchos*
	Common night hawk	*Chordeiles minor*
	Eastern kingbird	*Tyrannus tyrannus*
	Gadwall	*Anas strepera*
	Golden eagle	*Aquila chrysaetos*
	Great horned owl	*Bubo virginianus*
	Horned lark	*Eremophila alpestris*
	House sparrow	*Passer domesticus*
	Hungarian partridge	*Perdix perdix*

(Continued)

	Common Name	Scientific Name
Birds (continued):	Killdeer	*Charadrius vociferus*
	Lark bunting	*Calamospiza melanocorys*
	Lark sparrow	*Chondestes grammacus*
	Loggerhead shrike	*Lanius ludovicianus*
	Magpie	*Pica pica*
	Mallard	*Anas platyrhynchos*
	Marsh hawk	*Circus cyaneus*
	Mountain bluebird	*Sialia currucoides*
	Mourning dove	*Zenaidura macroura*
	Pintail	*Anas acuta*
	Pinyon jay	*Gymnorhinus cyanocephala*
	Red-headed woodpecker	*Melanerpes erythrocephalus*
	Red-shafted flicker	*Colaptes cafer*
	Red-tailed hawk	*Buteo jamaicensis*
	Red-winged blackbird	*Agelaius phoeniceus*
	Ring-necked pheasant	*Phasianus colchicus*
	Robin	*Turdus migratorius*
	Rusty blackbird	*Euphagus carolinus*
	Sage grouse	*Centrocercus urophasianus*
	Sharp-tailed grouse	*Pediocetes phasianellus*
	Shoveller	*Spatula clypeata*
	Sparrow hawk	*Falco sparverius*
	Upland plover	*Bartramia longicauda*
	Vesper sparrow	*Pooecetes gramineus*
	Violet-green swallow	*Tachycineta thalassina*
	Western kingbird	*Tyrannus verticalis*
	Western meadowlark	*Sturnella neglecta*
	White-breasted nuthatch	*Sitta carolinensis*
	White-crowned sparrow	*Zonotrichia leucophrys*
	Wilson's phalarope	*Steganopus tricolor*
	Yellow warbler	*Dendroica petechia*
REPTILES:	Bull snake	*Pituophis catenifer*
	Prairie rattlesnake	*Crotalus viridis*
	Racer	*Coluber constricter*

APPENDIX #8

ARCHAEOLOGICAL RECONNAISSANCE

By

University of Montana Foundation

Archaeological Reconnaissance and Salvage Excavations on Peabody Coal Lands, Rosebud County, Montana

Submitted to

Peabody Coal Company

In Fulfillment of Terms of Agreement
Between Peabody Coal Company and the
University of Montana Foundation
Dated 17 May 1971 and
2 September 1971

ARCHAEOLOGICAL RECONNAISSANCE AND SALVAGE EXCAVATIONS ON PEABODY COAL LANDS, ROSEBUD COUNTY, MONTANA

By
Dale E. Fredlund

Special Report from the

University of Montana Statewide Archaeological Survey

Floyd W. Sharrock, Director
Department of Anthropology
University of Montana
Missoula, Montana

August 1973

Petroglyph Tracings by Stephanie D. Fleischer

Other Drawings by Thomas J. Bryan

Photography by Lynn B. Fredlund

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Introduction

Archaeological reconnaissance and salvage excavation are aspects of the Peabody Coal Company's program for environmental protection and surface reclamation of lands in south central Montana which it plans to strip mine for coal. To help implement this program, on 17 May 1971 agents of Peabody Coal Company contracted with the University of Montana Statewide Archaeological Survey, through the University of Montana Foundation, to conduct an archaeological survey on the following lands in Rosebud County, Montana:

Township 1 North, Range 41 East, M. P. M.:
Section 13: SW 1/4; W 1/2, SE 1/4
Section 14: S 1/2; S 1/2, S 1/2, N 1/2
Section 15: SE 1/4
Section 21: SE 1/4, SE 1/4
Section 22: S 1/2; NE 1/4; E 1/2, NW 1/4; SW 1/2, NW 1/4
Section 27: W 1/2; W 1/2, E 1/2
Section 28: NE 1/4, NE 1/4.

It was anticipated that scheduled strip mining operations in these areas would destroy all surface features.

On 1 July 1971, the Statewide Archaeological Survey sent a seven-man crew into Rosebud County. The crew, consisting of graduate and undergraduate students in anthropology, was sent for the purpose of surveying and testing for archaeological deposits. The project was supervised by Dale E. Fredlund.

During the remainder of that summer, the survey crew recorded 17 archaeological sites. Of these, eight evidenced substantial cultural material on the surface or possessed other qualities that warranted their being tested for subsurface deposits. Test trenches indicated that four of these sites contained significant amounts of prehistoric cultural remains. Upon being appraised of these data, Peabody Coal Company agreed to a second contract which provided funds for archaeological salvage excavations at the following sites:

Site	Location
BLM Bison Trap, 24RB1021	T1N, R41E, Sec. 22, SE 1/4, SE 1/4, NE 1/4
Horse Shelter, 24RB1011	T1N, R41E, Sec. 27, N 1/2, SW 1/4, SE 1/4
Colt 45 Shelter, 24RB1012	T1N, R41E, Sec. 27, N 1/2, SW 1/4, SE 1/4
Tuma's Rock, 24RB1010	T1N, R41E, Sec. 27, N 1/2, SW 1/4, SE 1/4.

The bulk of this report includes geographical and historical background information relevant to the survey area, and detailed descriptions of the archaeological sites and artifacts found by the survey crew. Other interpretive data are included in the summary and conclusion sections.

Topography

In general, the survey area (Figs. 1 and 2) can be described as the slopes of a main ridge that extends eastward from the Little Wolf Mountains (22 mi. to the west). More specifically, it is the height of land separating the Rosebud Creek drainage on the south from the Armells Creek drainage on the north. The area has an elevation of approximately 3600 ft. above sea level and includes the flats and slopes around Miller Coulee (Fig. 3). Rosebud Creek, 3 mi. south of the survey area, is the only permanently flowing creek in the immediate area. Miller Coulee and Armells Creek, although dry most of the year, sometimes contain pockets of standing water and have some small seeps. Occasional springs are the only other water sources in this region.

The predominant geologic strata, from which most of the area's rock outcrops were formed, are the Tongue River member of the Fort Union formation and the overlying Wasatch formation. These horizontally bedded sedimentary rock formations are of tertiary age, and consist of alternating layers of sandstone shales and coal (Baker 1928:24).

The topography is unique in that it contains only two primary ecosystems (Fig. 4). One ecosystem includes the dendritically patterned ridges that have been carved from sandstone of the Fort Union formation. These ridges owe their existence to the erosion-resistant caprock of porcelanite and clinker which was formed when ancient beds of coal burned. Through metamorphosis, adjacent silt strata were turned into red and gray porcelanite. Erosion has carved these ridges,

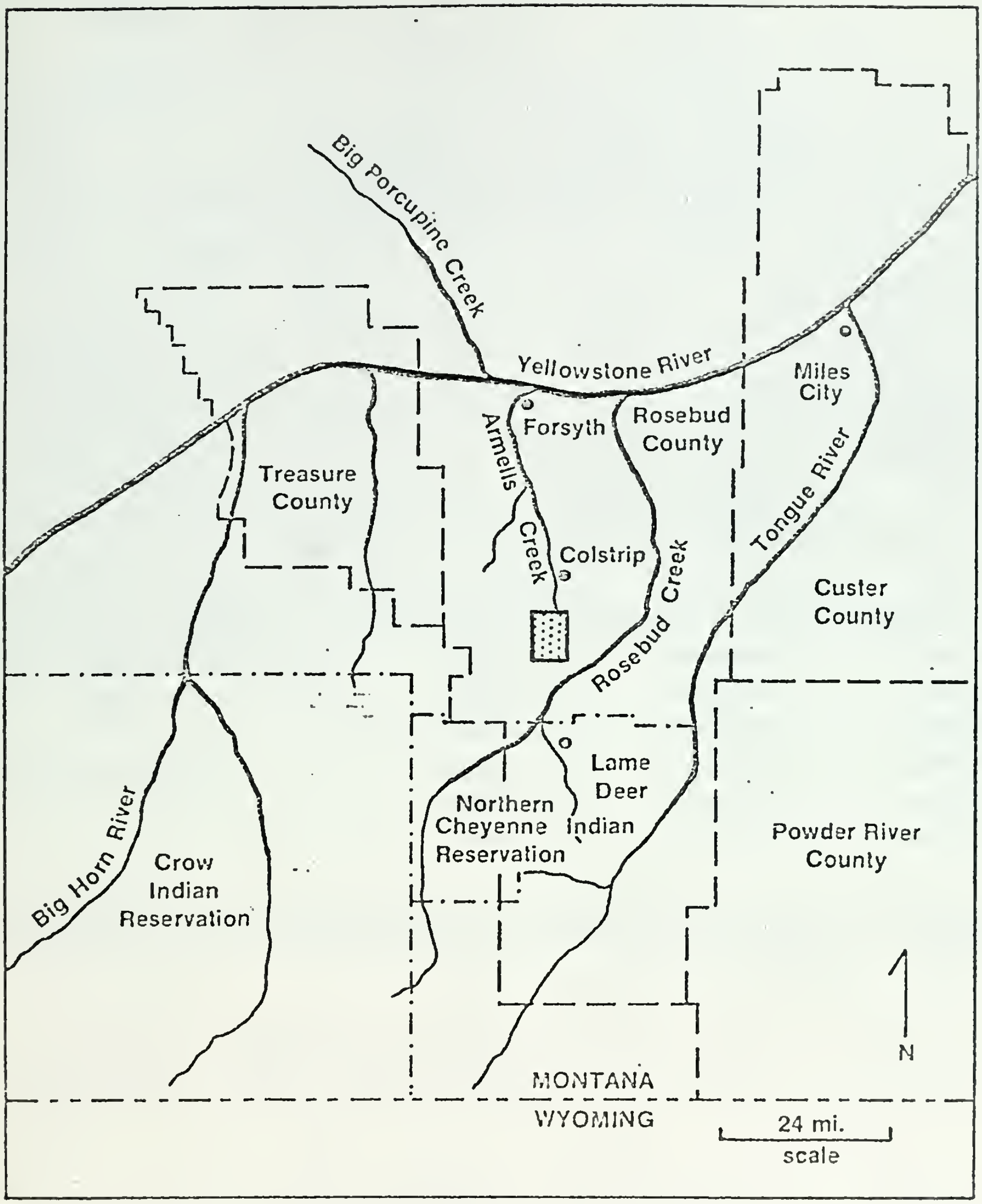

Fig. 1. South central Montana, map showing the general location of the survey area (shaded).

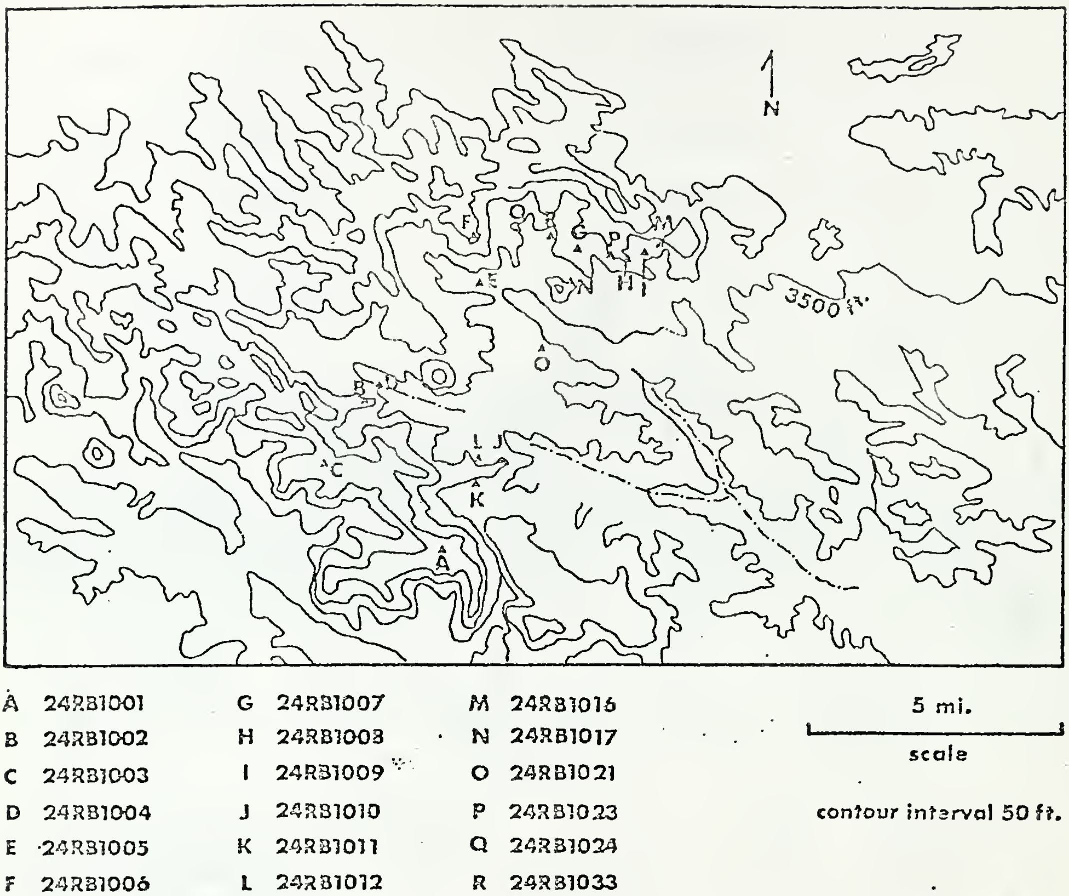

Fig. 2. Contour map of survey area, showing locations of archaeological sites found.

leaving numerous rockshelters, crevices, and holes in the vertical sandstone faces. Scattered ponderosas and junipers compose the dominant or climax plant species in this ecosystem, while native grasses, sage, and prickly pear cactus form the ground cover.

The second major ecosystem is located in the relatively flat grassy basins that separate the ridges. These basins are usually dissected by a dendritic system of dry washes which was created by the run off of water from sudden and violent thunderstorms.

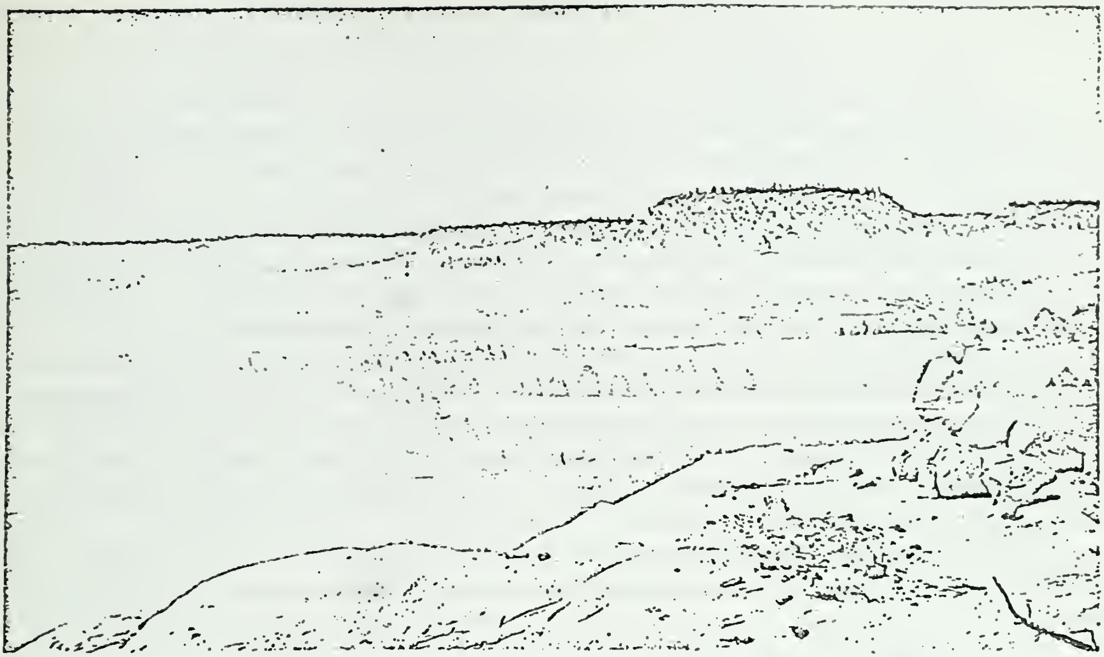

Fig. 3. Miller Coulee and surrounding grasslands, view to south from Lookout Point site (24RB1007).

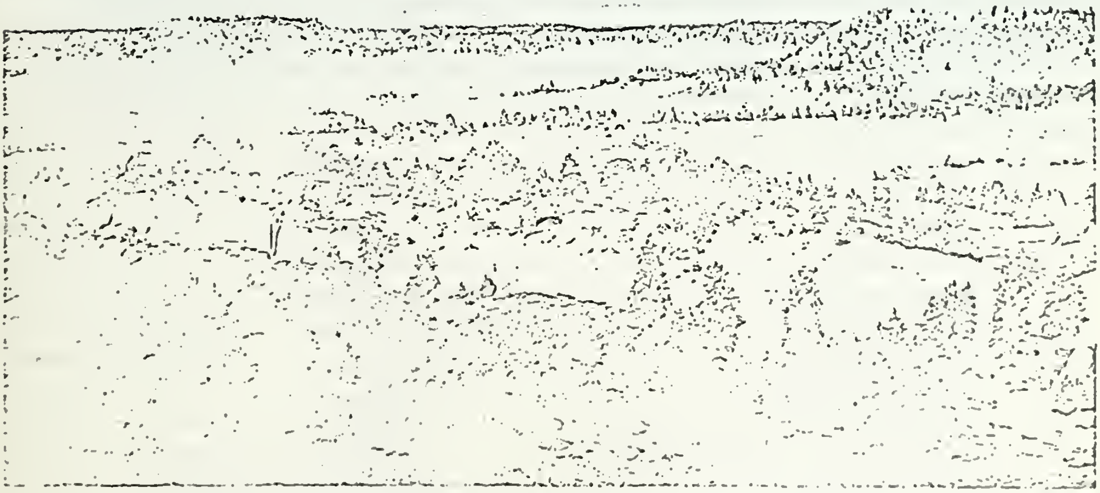

Fig. 4. View, looking to southwest, showing general topography of survey area.

Climate

Using the Holdridge system (Holdridge 1967) for determining climate, one may classify south central Montana as subhumid short-grass plains or steppe. The hottest month of the year is July, when temperatures average around 70° Fahrenheit; December is usually the coldest month, with temperatures averaging near 20°. The mean annual precipitation is approximately 15 in., one-third of which is snow, with May and June being the wettest months. There is an average of 125 frost-free days. The growing season for native plants ranges from March to June (Hodder *et al*. 1970:2), and the first frost usually arrives around mid-September.

In the winter season, temperatures may drop to as low as -40° Fahrenheit, but these cold periods are generally short-lived, since warm chinook winds frequently bring sudden pronounced temperature changes. Snow falls in quantities varying from a few inches to several feet at a time. Winds usually sweep the snow clean from the ridges and flats and pile it in large drifts on the lee side of hills or in dry washes.

The region is primarily arid, and snow or rain usually comes in short, violent storms. Frequent summertime flash floods erode the land into a web of gullies.

Flora and Fauna

The principal grasses of the short-grass plains include *Bouteloua gracilis*, *B. hirsuta*, *Buchloe dactyloides*, and *Hilaria jamesii* (Shelford 1963:344). Interspersed throughout the grassy flats, sagebrush, rhus, yucca, and prickly pear cactus flourish. Cottonwood thrives in the more moist areas along stream courses. On the sandstone ridges, juniper and ponderosa pine grow in sparse stands.

The food plants available to prehistoric peoples who lived on the Northern Plains included (Mulloy 1958:20-21):

Box elder
Currant
Wild plum
Sand cherry
Chokecherry
Buffaloberry
Prairie plum
Wild red cherry
Prairie potato
Wild grape
Ground cherry
Sunflower
Wheat grass
Prickly pear
Raspberry
Serviceberry
Hawthorn
Milkweed
Buffalo pea
Gooseberry
Dock
Indian rice grass

Giant wild rye
Onion
Wolfberry
Burroak
Bitterroot
Bearberry
Sego lily
Goosefoot
Valerian
Elderberry
Oregon grape
Snowberry

The short-grass plains environment traditionally has supported an abundance and variety of animal life, a factor which made the region attractive to human populations. Of primary importance in late prehistoric and early historic times were the large ungulate species, especially the bison. Butzer (1964:140) estimated these animals to have once numbered as many as 60 million. Understandably, bison were one of the main food resources of Indians who inhabited the Plains. Because people depended on bison for subsistence, and bison were migratory by nature, the movements of bison affected patterns of human migration. However, it is difficult to correlate human population movements with bison migration because our knowledge of the migratory patterns of the bison is obscured by contradictory studies. Shelford (1963:344), for example, states that bison migrated northward over a range of 200 to 300 mi. each spring, then returned southward in early winter. Garretson (1938:52), on the other hand, holds that the primary movement of bison in the northern portion of their natural range was from east to west--from the foothills of the mountains in the winter to the Plains in the spring and summer, and back to the foothills by late fall.

Other game animals of importance to peoples on the Plains were pronghorn antelope, elk, white-tailed and mule deer, grizzly bear, and black bear, all of which existed in great numbers in the area. Bighorn sheep also would have been found near the foothills. On the whole, the grazing characteristics of the ungulates (taking only a few bites from any single plant), together with their movement patterns, served to enrich and perpetuate the short-grass prairie conditions.

Rodents constituted an additional food resource for many predator species on the Northern Plains, including man. The more common rodents included beaver, muskrat, porcupine, mouse, mole, ground squirrel, packrat, and gopher. Both white-tailed jackrabbits and cottontail rabbits were abundant in the area. Common predators included the coyote, mountain lion, mink, otter, fox, bobcat, skunk, brush wolf, ferret, weasel, badger, golden and bald eagle, and several species of hawks and owls. Perhaps the most famous natural predator of the Plains was the "lobo," or buffalo wolf, that harrassed the bison herds, preying upon the old, crippled, and sick, as well as the calves when possible. The rattlesnake, bull snake, and the plains garter snake inhabited the region as well, being both predator and prey.

According to Shelford (1963:346), the more common small birds inhabiting the region included:

Horned lark
McCowan longspur
Chestnut-collared longspur
Lark bunting
Sprague's pipet
Brewer's sparrow

Lark sparrow
Western meadowlark
Grasshopper sparrow
Lesser prairie chicken

Migratory waterfowl, sagehen, and grouse were also common, as were the scavenger birds--crows, magpies, blackbirds, and ravens.

With an environment so rich in game, it is not surprising that man has occupied the area for thousands of years.

Prehistory and History of South Central Montana: Background Statement

> Our country is the most beautiful of all. Its rivers and plains, its mountains and timber lands, where there was always plenty of meat and berries, attracted other tribes, and they wished to possess it for their own. (Linderman 1962:47-48)

Thus Plenty Coups, chief of the Crow Indians, described the lands of south central Montana which were occupied by his people at the time of white contact. The Crow, the Cheyenne, the Blackfeet, and the Dakota Sioux are known to have been the last Indian inhabitants of this area, and their lifeways have been fairly well documented by ethnohistorical and ethnographical studies (Curtis 1911; Ewers 1958; Lowie 1954; Wissler 1927). Our knowledge of the specific occupants of the area and their lifeways before the time of the protohistoric is incomplete. Archaeological data suggest that humans had already spread throughout the Northern Plains area by approximately 13,000 years ago. These original inhabitants participated in the big game hunting complexes that have come to be called Clovis and Folsom. These terms label broad cultural categories and are based on the fact that particular projectile points were used over many hundreds of years.

Early Prehistoric Period

The florescence of the Clovis and Folsom traditions occurred around 12,000 B. C. and 10,000 B. C., respectively (Jennings 1968). Clovis hunters apparently sought out mammoths as their major source of food, while Folsom peoples hunted now-extinct forms of bison. Fluted points were characteristic artifacts in both traditions. Occasional miscellaneous surface finds indicate that the Northern Plains was utilized to some degree by these early hunters. Also, but less frequently, the fluted points are recovered in subsurface sites, such as the Wilsall site (24PA507) near Wilsall, Montana (Taylor 1969), which contained artifacts belonging to the Clovis tradition, and the MacHaffie site near Helena, Montana (Forbis 1952), which contained Folsom artifacts.

By approximately 8000 B. C., these early hunters began to manufacture a variety of new projectile point types. The new point styles were generally long lanceolate points, lumped by archaeologists under the name of Plano and classified into two variations, Plainview and Parallel Flaked (Willey 1966:44). Like the Folsom hunters, Plano peoples were hunters of the ancestoral forms of modern bison, but the area they inhabited was more extensive. Plano peoples spread throughout the Northern Plains, and possibly became the first peoples to occupy Alberta intensively (Wormington and Forbis 1965:185).

Middle Prehistoric Period

The Plano tradition began to wane around 5000 B. C., as the initial phases of the altithermal began. This major change in climate probably created slightly warmer and drier conditions than had existed previously. The altithermal is hypothesized to have altered the environment to the extent that the lifeways of the inhabitants of the Plains necessarily had also to change.

> Buffalo hunters of the northern plains at the beginning of the altithermal were probably obliged to move to more favored regions to the north and east, or their numbers were reduced in accordance with the natural resources available (Wormington and Forbis 1965:191).

Bryan and Gruhn (1964) suggest caution in treating the altithermal as a fixed time period of "climatic periods with defined characteristics." Instead they suggest that the altithermal be considered a phase of the neothermal temperature curve which in "different ecological areas resulted in locally varying climatic conditions...."

It is known that the food resources of peoples during the Middle Prehistoric Period became more diversified. Vegetable foods were apparently utilized more frequently (Wedel 1964:201), and although limited big game hunting continued, smaller animals, such as rodents, became a more important part of the diet. Because of the increased variety of foods they exploited, the term "foragers" has been applied to the peoples of the Northern Plains during this period (Malouf 1957). With the change in the food resources, there was an accompanying change in technology. Grinding stones first appear in artifact assemblages of sites belonging to this period. The projectile points made were smaller in size when compared with the large blades used by hunters in the Early Prehistoric Period. The new projectile point types developed during this time period (3000 B. C. to A. D. 500) include Oxbow, the McKean complex, Pelican Lake, and Besant.

Late Prehistoric Period

Another transition in the lifeways of the inhabitants of the Northern Plains began about A. D. 500, and this date also marks the beginning of the Late Prehistoric Period. The cultural change that took place at this time was one of degree rather than of kind, and the change was very gradual. It is believed that a greater dependence on the bow and arrow, rather than on the atlatl (spearthrower) occurred. With the advent of the bow and arrow, new point types were developed which Kehoe (1966) calls the small side-notched point system of the Northern Plains. Also, the use of pottery increased. There is some indication that the number of bison increased, and consequently more people could be supported by this resource. New people practicing horticulture, as evidenced at the Hagen site (Mulloy 1958:218), moved into the area of eastern Montana late in the period.

Perhaps the most significant change during the last part of this period was the introduction of the horse in the sixteenth century, an addition to the economic potential which effected some degree of change in nearly every aspect of Indian culture. So important was the horse to the late tribes that Wissler (1927:154) has termed the period from 1540 to 1800, during which time the horse diffused to all the tribes on the Plains, as the "horse culture period." Changes brought about by the introduction of the horse were dramatic but were superimposed on previous economic patterns. Beardsley (1956:147) describes the Plains Indian horse complex as being "equestrian hunting, that is, hunters and gatherers who possess the horse as a domesticated animal but use it primarily as a tool for hunting rather than a food resource."

Prior to the introduction of the horse, Plains people walked and used dogs for beasts of burden. Thus travel was restricted by human endurance, and the areas that people occupied were determined by their proximity to water and fuel. Kroeber (1939:87) credits the horse with making the vast Plains a desirable place to live in spite of the area's lack of water and fuel resources. On acquiring the horse, native peoples greatly increased their range. They began to move into the Plains from east and west to occupy areas that were previously used only marginally, if at all. Before the existence of the horse-bison complex, the Plains, with the exception of the river valleys, had certainly not been utilized as extensively by such large groups as they were later.

It was these equestrian hunters who inhabited the Northern Plains at the dawn of the historic period, but most of the groups were relative newcomers to the area. These historic tribes had been pushed into the area by warfare and population pressures from their eastern neighbors. The historic Plains tribes, upon arriving in the Northern Plains, assuredly displaced other tribes. One of these was the Shoshone who, having received the horse first, apparently controlled a major portion of southern Montana until they were forced southward into Wyoming by the raiding Blackfeet (Malouf 1957; Wedel 1964:212). It is certain at least that some tribes such as the Flathead, Pend d'Oreille, and Kutenai did live on the Plains at least seasonally before they were forced to move to the western slopes of the Rocky Mountains by the more powerful newcomers.

Historic Period

Just prior to and at the time of white contact, aboriginal ownership of those lands which have now become south central Montana and northern Wyoming was in a state of flux, as it was in the rest of the Northern Plains.

The Crow tribe, having separated from the Hidatsa around 1750 (Dearss 1970:2), had moved into the area from the east and claimed a major part of what is now south central Montana. Their territorial claims centered on the area along the Bighorn and Yellowstone rivers, and they were the primary occupants of the region in early historic times. However, by the middle of the nineteenth century, they were fighting to retain their ownership. Crow territorial claims were constantly challenged in the mid-nineteenth century by the Teton Dakota who moved west as far as the Powder River. On the south, the Northern Cheyenne hunted ever northward, extending into Crow country. From the north, the powerful Blackfeet and Atsina tribes harassed the Crow, and threatened to expand into the northern part of Crow lands (Ewers 1958:77). Surrounded by such powerful enemies, the Crow aligned themselves with the whitemen and aided the frontier armies of the United States during the Indian wars of the latter part of the 1880's. After the "winning of the west" by government forces, the Crow, largely because of their role as an ally during the Indian wars, were able to retain much of their land.

At the same time that tribes were struggling for territorial control in south central Montana, whitemen began to evidence interest in the region. The exact date of first Indian-white contact is not known, but one of the first whitemen to venture into the region was Pierre la Verendrye in 1743 (Laut 1904). Shortly afterward, fur trappers were lured into the region. Their stories and accounts stimulated general interest in the Yellowstone country, and in 1803 the United States government established its first claim to the region by the Louisiana Purchase. Subsequently, in 1804, Lewis and Clark were dispatched to explore the area.

In 1822, the Atkinson expedition was sent by the United States government to the Yellowstone country to establish peace treaties with the tribes. Because of continued white expansion, the treaties failed, and the stage was set for the Indian wars of the late nineteenth century. In 1864, John Bozeman led a wagon train of immigrants through the region, establishing a route through the Indian hunting grounds that became known as the Bozeman Trail. Shortly afterward, in 1866, Nelson Story made the first cattle drive to Montana. Resenting these and many other incursions into their hunting grounds, the Northern Cheyenne, followed shortly by the Dakota Sioux, fought to retain their lands.

The Indian wars of the Northern Plains reached their peak intensity in 1876 when General Crook marched up Rosebud Creek and encountered the Northern Cheyenne. On 17 June the battle which the Cheyenne refer to as "Where the Girl

Saved Her Brother" (Stands in Timber and Liberty 1967:181) or the "Battle of the Rosebud" was fought. A week later, on 15 June 1876, General Custer found the Sioux and Cheyenne camped on the Little Bighorn River and made his fateful charge. Although "Custer's Massacre" was a victory for the Sioux and Cheyenne, their efforts to retain their land and freedom were a lost cause. By 1884 the Northern Cheyenne Reservation had been established. White settlers were soon entering the region, and the era of large cattle, horse, and sheep ranching had arrived.

The Archaeological Reconnaissance: Descriptions of Sites

An archaeological reconnaissance, or survey, can be defined simply as an inventory and field reconnaissance of a region's archaeological resources. Initial phases of the present survey involved seeking the respective landowners' permissions to survey their lands and discussing with them locally-known archaeological sites. The sites reported by the landowners, although not necessarily located on the survey lands proper, provide background information relevant to an understanding of the region's prehistory. Actual field survey was conducted by systematically walking over all the land surfaces designated by our contract and looking for evidences of prehistoric and early historic habitation. By covering the terrain in an organized pattern all hills, flats, and ridges were investigated and searched. We walked through all dry washes and examined the cutbanks for subsurface archaeological sites that might have been exposed by erosion. All sites found were numbered according to the Smithsonian trinomial system* and recorded on Statewide Archaeological Survey forms. Photographs were taken, and if the site warranted further attention, it was tested and mapped. All field notes, artifacts, photographs, and maps are on file at the Statewide Archaeological Survey office.

During the course of the survey, a total of 17 archaeological sites were located (see Fig. 2). These can be divided into six types: lookout stations or observation posts, open habitation sites, rock art panels, quarries, bison kills, and rockshelters. Descriptions of the sites, arranged according to site type, follow; artifacts are described in the artifact section of the report.

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*The Smithsonian system for site designations standardizes site numbering throughout the United States. Each site designation includes a number representing the position of the state within an alphabetical listing of all states, excluding Alaska and Hawaii (for example, 24 for Montana); initials representing the county within which the site is located (for example, RB for Rosebud County); and a number that has been assigned to that specific site within that county (for example, 1012). Thus, a site may be designated as 24RB1012.

Lookout Stations or Observation Posts

Our crew found that sites were located most often along the tops of sandstone ridges. Prehistoric activities were evident in the small areas containing scattered lithic debris (waste rock flakes from tool manufacture) that were found on these ridges. These sites seem to have functioned as lookout stations because their location usually provided an excellent view in at least one direction of the terrain below. Unless these lookout sites evidenced repeated use, we did not assign site numbers to them. Often we found only several flakes, and these suggest nothing more than the fact that someone passed by once during the prehistoric past.

24RB1001, Wind Devil Site

Location: Sec. 28, T1N, R41E

Site 24RB1001 was located on the ridge crest 100 yd. south of Peabody Coal Company's Big Sky Mine. From the top of the ridge, the view of Miller Coulee was excellent. Rock flakes resulting from lithic tool manufacture, and a few artifacts were scattered over an area 20 ft. by 20 ft. on the northwestern end of a grassy, open area.

Artifacts recovered: End scraper (1 small flake end scraper)
Preforms (2)

Site vegetation: Native grasses, yucca, cactus, juniper, sage

24RB1002, Hot Dog Site

Location: Sec. 21, T1N, R41E

Site 24RB1002 was located on a hill 1/2 mi. west of the Peabody mine and near the "Y" of the powerline. This site provided a good view over the Miller Basin. One hundred yards northeast of this site, we located a small chipping station.

Artifacts recovered: Although flakes of red and gray porcelanite were abundant, no artifacts or retouched flakes were found.

Site vegetation: Sparse native grass, juniper, ponderosa pine, cactus

24RB1003, Cicaida Site

Location: Sec. 33, T1N, R41E

This site was located on the crest of a ridge southwest of the Big Sky Mine. An excellent view of Miller's Coulee was afforded from the site. The site covered an area approximately 30 ft. by 15 ft. and may have been associated with quarrying activities.

Artifacts recovered: No tools were found, although large spalls were abundant.

Site vegetation: Juniper, ponderosa pine, sage, yucca, cactus, native grasses

24RB1007, Lookout Point Site

Location: Sec. 14, T1N, R41E

Site 24RB1007 was located on top of the second high sandstone remnant 1/3 mi. north of the Big Sky Mine tipple. This site provided an excellent view of the badlands to the east as well as to the west toward 24RB1005, the Dead Cow site. At the base of this sandstone remnant on a vertical face the crew found petroglyphs of what appear to be small anthropomorphic figures and an unidentifiable animal (see 24RB1033). To the side of the vertical face on which the rock art panel appeared, the sandstone remnant sloped upward, thus providing the only easy access from the remnant's southern side to the top of the outcrop and the lookout station location there.

Flake concentrations were found in several places on the outcrop, but the primary lookout station apparently was located on the southern edge. There lithic material was scattered over an area measuring 20 ft. by 20 ft. Because of this limited size, we conducted a grid pick-up of all lithic material on the site (i.e., we collected all surface debitage within marked squares), in an effort to gain better insight into activities of the prehistoric occupants of the site. The results of this analysis were inconclusive.

Lookout Point (Fig. 3) is an outstanding example of the lookout sites in the survey area, even though it consisted of little more than a concentration of flakes within a limited area. The site location provided concealment for the users, yet permitted excellent observation of the adjacent low-lying terrain. There is little doubt as to the utilization of the site as a lookout station. None of the attributes that are necessary for a habitation site (primarily shelter and water) were present. Nor does it seem likely that the site was a fortifaction. Access was easy from the northern side of the outcrop, so it would have been difficult to defend. We found no evidence of fortification structures.

Artifacts recovered: Side-notched projectile point (1)

Site vegetation: Ponderosa pine, juniper, native grasses

24RB1008, Pyramid Mountain Site

Location: Sec. 14, T1N, R41E

Site 24RB1008 was another lookout station located on the rock outcrop just east of 24RB1007. At the site were natural rock formations in which an observer could conceal himself, and the site offered a panoramic view of the territories to the east and south. Chips of red and gray porcelanite were scattered over a surface area located approximately 100 ft. just below the ridge's crest.

Artifacts recovered: Biface fragments (2)
Site vegetation: Yucca, sage, ponderosa pine, native grasses

Open Habitation Sites

Open habitation sites were usually located on open flats adjacent to a permanent water course. These sites were temporary camping spots.

24RB1004, Cottonwoods-Water Site

Location: Sec. 22, T1N, R41E

Site 24RB1004 was located on a sage-covered flat in Miller Coulee. The surface area was approximately 100 yd. by 75 yd. and spanned the creekbed in the coulee. The creek currently contains water for only part of the year. Its location is concealed from the main basin of Miller Coulee north of the mine. The cultural deposits of the site were limited to the surface.

Artifacts recovered: Projectile point (1 unidentifiable fragment)
Bifaces (5 crude bifaces)
Scrapers (5 flake side scrapers)
Site vegetation: Willow, small cottonwoods, chokecherry, rhus

24RB1005, Dead Cow Site

Location: Sec. 15, T1N, R41E

Site 24RB1005 was located on the flats adjacent to Miller Creek, 1/4 mi. west of the Big Sky Mine's railroad loading spur. The surface area of the site extended for about 300 yd. along both sides of the stream. The site terminated in pine and rock outcroppings at its northwestern end. Several structures that appear to be long walls built of rock slabs (Fig. 5) were found within the eroding rock outcrop. Lithic detritus, as well as tin cans, were found surrounding and within the rock structures, thus we were not able to determine whether the structures were prehistoric or historic in origin.

Despite apparently repeated surface collecting by amateurs, site 24RB1005 yielded a number of artifacts.

Artifacts recovered: Projectile points (3 corner-notched, 1 side-notched)
Scrapers (1 keeled, 2 side, 1 flake)
Bifaces (5)
Multipurpose tools (4)
Site vegetation: Juniper, sage, cottonwood, willow, ponderosa pine, cactus, chokecherry, rhus, native range grasses

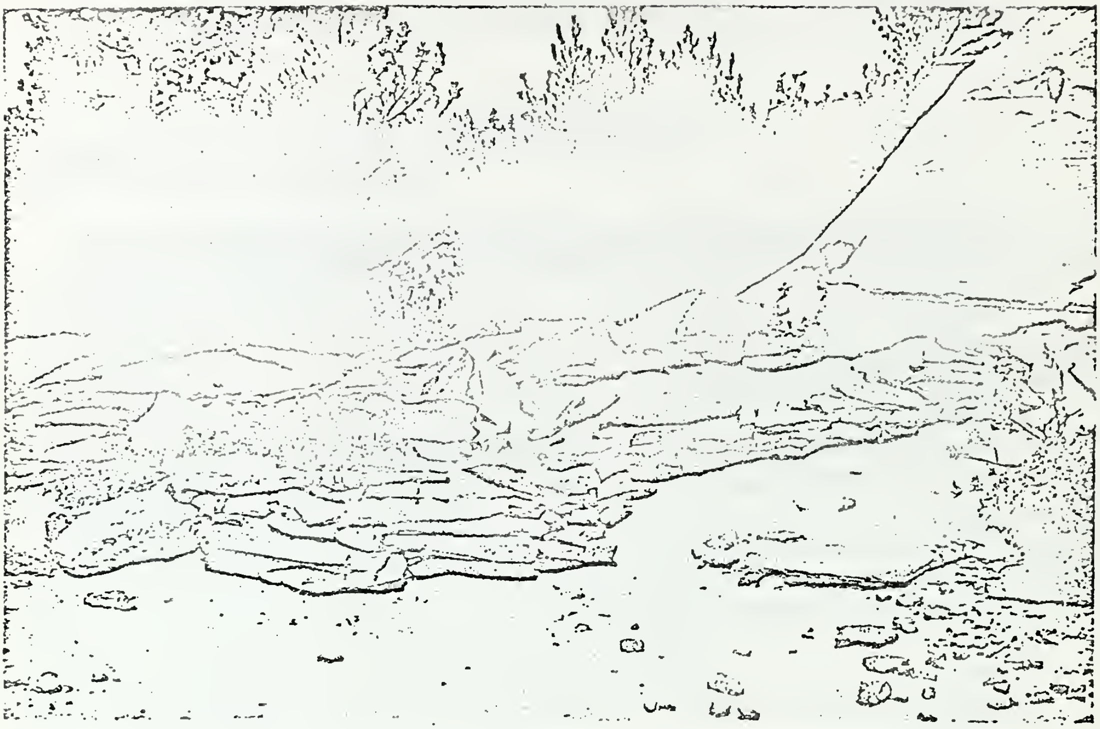

Fig. 5. Rock structures at 24RB1005.

24RB1009, On-the-Way-Home Site
Location: Sec. 14, T1N, R41E

Site 24RB1009 was a small surface site located directly below 24RB1008 on the eastern side of the same sandstone outcrop. The site was bisected by a gully and covered an area measuring 50 yd. by 25 yd. Large spalls of red and gray porcelanite lay on the surface.

While water would have been immediately available for only a short period of time during the spring of the year, the inhabitants of 24RB1009 could have utilized snow during the winter season. During this season, the site's location would have provided protection from the wind. There was, however, no indication that the site was ever occupied for any great duration of time.

Artifacts recovered: Pyriform biface (1 fragment)
Flat-backed flake scraper (1)
Reworked blade-like preform (1)

Site vegetation: Ponderosa pine, sage, cactus, rhus, yucca, juniper, native prairie grasses

Rock Art Sites

As Mulloy (1958:119) has suggested, the value of rock art to anthropology lies primarily in the fact that material culture is often illustrated, and art might possibly be useful in determining cultural relationships. Thus such sites deserve considerable attention.

Rock art in south central Montana can be divided into two basic categories: pictographs or paintings, and petroglyphs. The latter were made by rubbing or pecking grooves or lines into the rock surface. Design elements may be very similar in both art media. In south central Montana, petroglyphs appear to be the most frequently occurring form of rock art. This art technique was probably preferred in this area because of an abundance of soft sandstone surfaces that are ideal for carving. All the rock art discussed in this report is of the petroglyph type. Pictographs, although present in the general area, did not appear to be abundant, possibly because erosion destroys them and the soft sandstone is not conducive to this art medium.

Although accurate techniques for dating rock art have not been developed, there are several general chronological indicators that provide some insight as to the time when they were made. One of these indicators is the figures or elements themselves. Historic items such as guns, for example, reflect white contact. Horses also reflect a relatively recent time period, since the horse reached the Northern Plains only after 1540. Conner and Conner (1971:12) suggest that perhaps there is a "trend toward more skillful draftsmanship with the passage of time," and that "prehistoric or historic period sites demonstrate the shift from front view motionless pictures of people to animated side view realistic art."

Superimposition of art figures, while helpful in determining which figures were constructed first, does not as yet provide insight as to which prehistoric time periods are represented. It is even more hazardous to attempt an interpretation of the meaning of the drawings. Mulloy (1958:199) states that:

> Their pictographic significance must remain obscure however, for such symbolism is a highly individualized thing, capable of decipherment only by the original artist and his community.

Recently Stuart W. Conner (personal communication 1971), Richard Colberg (personal communication 1971) and Malouf and White (1953) have reported cultural interpretation of probable Crow Indian and Kutenai Indian rock art sites by members of the Crow and Kutenai communities, respectively. These interpretations may help explain figures' dress and the various actions illustrated on the panels.

In efforts to establish cultural relationships, archaeologists have given considerable attention to several recurrent motifs. The more important motifs recognized by Mulloy (1958:118-39) and Conner and Conner (1971:14-27) in Montana and northern Wyoming rock art sites include:

1) Shield-bearing anthropomorphs with only the head and legs protruding from behind the shield
2) Rectangular-bodied anthropomorphs with solid or outlined bodies whose legs are extensions of the vertical lines forming the body trunk
3) Three-quarter view anthropomorphs utilizing curved lines and showing facial profile and frequently depicting action
4) V-necked anthropomorphs
5) Stick-figured anthropomorphs
6) Hand prints
7) Tipis
8) Animals

Our procedure for recording rock art sites was to complete a standard Smithsonian-style site form, as well as a more specific rock art form designed by Stuart W. Conner, of Billings, Montana. Photographs of the figures were taken from several angles, and finally a sheet of Visqueen plastic was placed over the panel, and the figures were traced with a fine-line felt-tipped pen (not all pens will work on Visqueen). The finished tracing was then sprayed with a clear plastic spray, thus fixing the ink and preventing smearing or running in case of contact with moisture. This recording technique proved to be effective, and a full-sized exact reproduction of the panels could be kept for the records.

24RB1016, Big Cut Bank Fish Site
Location: Sec. 14, T1N, R41E

Site 24RB1016 (Fig. 6) was located on a southeast-facing cliff face of a small sandstone remnant 1/3 mi. west of the Peabody Coal Company's trailer court. The petroglyphs were carved into the sandstone about 18 in. above the present ground surface, and covered a panel approximately 3 ft. long.

Erosion has almost destroyed the petroglyphs, and in a few more years they will be indiscernable. We are not certain as to what they represent.

Artifacts recovered: None

Site vegetation: Rhus, sage, juniper, cactus, native range grasses

24RB1023, Pyramid Mountain Petroglyph Site
Location: Sec. 14, T1N, R41E

Site 24RB1023 (Fig. 7) was located on the sandstone rimrocks 1/3 mi. west of the Peabody Coal Company's trailer court and 1/2 mi. north of the Big Sky Mine headquarters.

The petroglyphs were worked into the face of a southwest-facing cliff. They were situated approximately 4 1/2 ft. above the present ground surface, and occupied a surface area approximately 4 ft. wide by 1 1/2 ft. high. The glyphs were badly

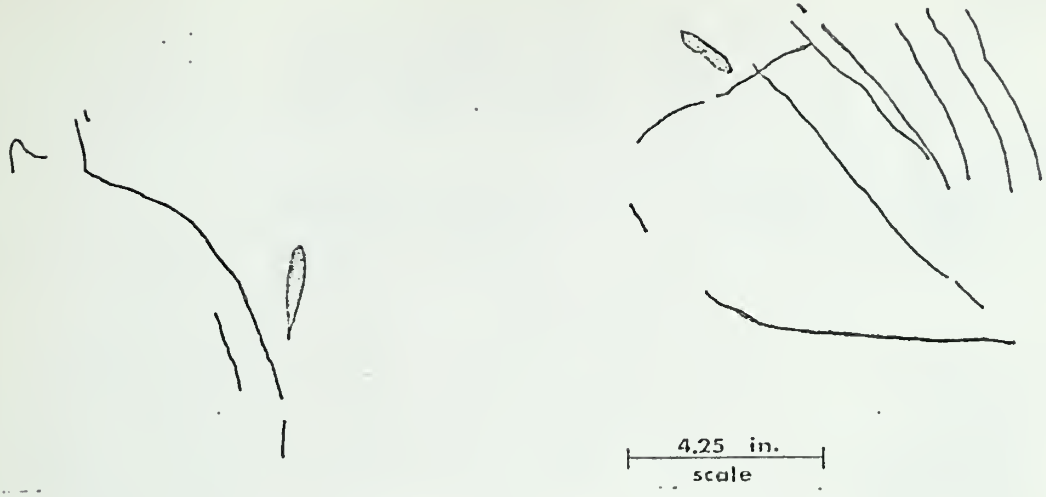

Fig. 6. Petroglyphs at 24RB1016, Big Cut Bank Fish site.

eroded. There was no evidence of superimposition on any of the glyphs. Although several rock art components were present, only a single V-necked anthropomorph can be definitely identified.

Artifacts recovered: None

Site vegetation: Rhus, shrubs, range grasses, sage, juniper

24RB1010, Tuma's Rock Site
Location: Sec. 27, T1N, R41E

Site 24RB1010 was a prehistoric-historic petroglyph site that was first reported to us by Gene Tuma of Peabody Coal Company. A major portion of the site's vertical face collapsed shortly after being recorded. This site was a rock art site with subsurface cultural deposits. It was situated on the first rock outcrop west of the Big Sky Mine, and approximately 100 yd. south of 24RB1012, Colt 45 Shelter (Fig. 15). The predominant feature on Tuma's Rock was an historic petroglyph of a bicycle with the inscription "Road King George 1898" (Fig. 8). The bicycle glyph was one of two panels present at the site, each of which was approximately 5 ft. 6 in. above the present ground surface.

The second panel, of prehistoric rock art (Fig. 9), was 2 ft. 6 in. in width and 3 ft. 6 in. in height, and showed what appears to be a shield-bearing anthropomorph carrying what may be a spear. A line from the contact point of the figure's hands on the spear leads to a circular object with an interior design. What appears to be a domed tipi and an arrow complete the panel.

Test excavation of site 24RB1010 is discussed in the excavation section of this report.

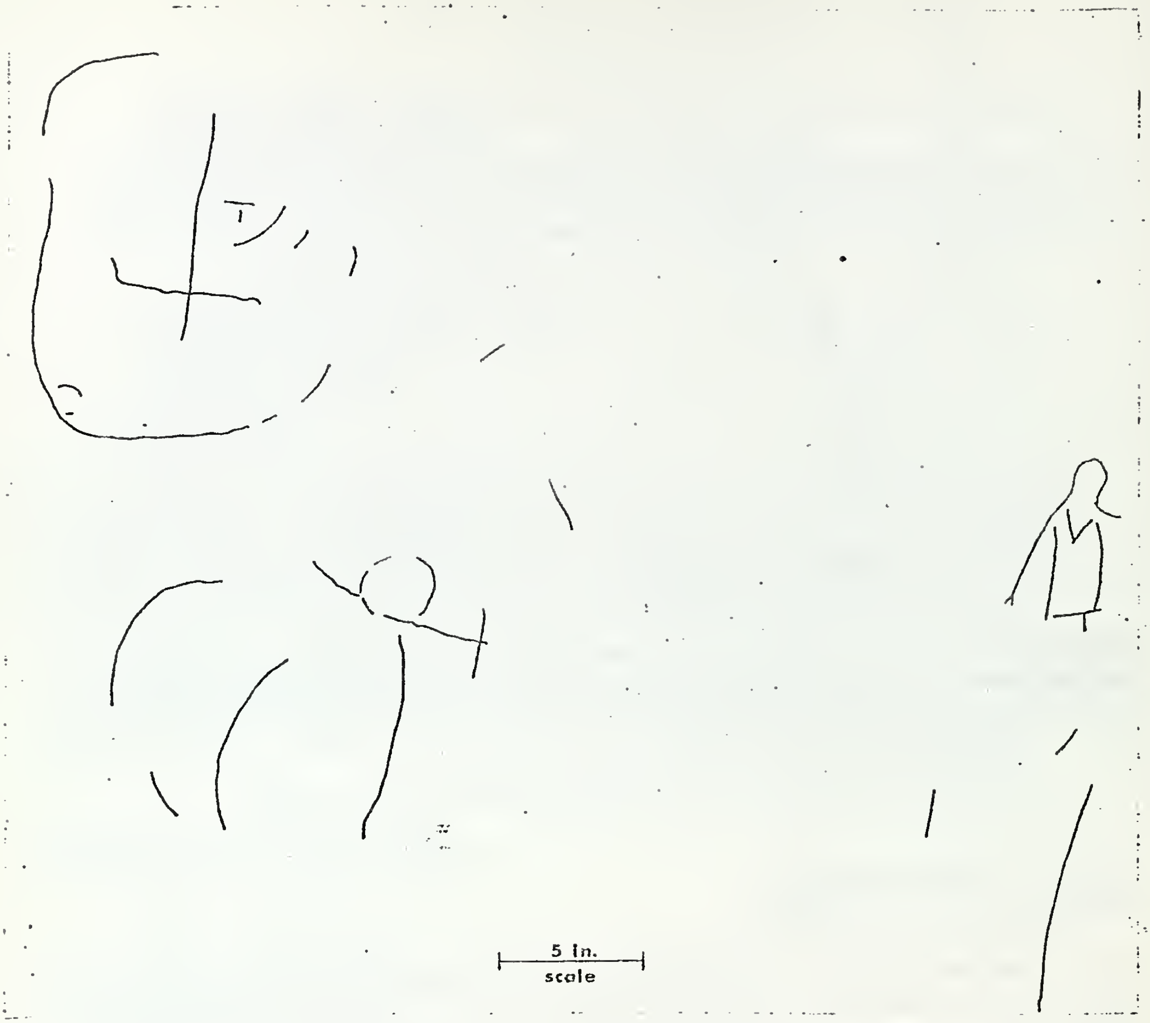

Fig. 7. Petroglyphs at 24RB1023, Pyramid Mountain Petroglyph site.

24RB1033, Lookout Point Petroglyph Site
Location: Sec. 14, T1N, R41E

This rock art site was situated on the vertical face of the same sandstone remnant as site 24RB1007. Whether there is any relationship between the petroglyphs at 24RB1033 and the lookout station at 24RB1007 is not known.

The panel was approximately 8 ft. long and 3 ft. wide, and was drawn about 6 to 8 ft. above the ground. The figures appeared in a single panel, and include what seem to be three stick figure anthropomorphs (Fig. 10). One holds in its hand what appears to be a shield and spear similar to those held by the anthropomorphic figure in the panel at 24RB1010. A fourth figure may be anthropomorphic, but is difficult to identify for certain. Another figure appears to be a crude

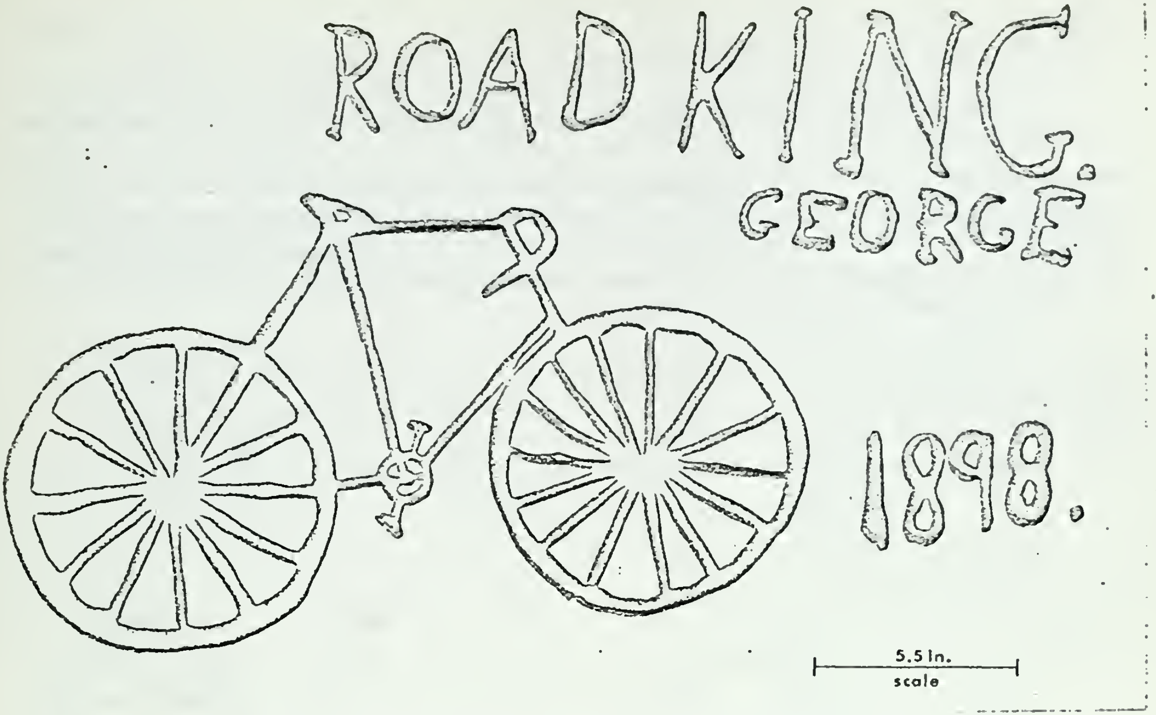

Fig. 8. Historic petroglyph at 24RB1010, Tuma's Rock site.

zoomorphic creature, possibly a deer. The remaining carvings consist of lines and peck marks.

24RB1017, Trailer Court Cave Site
Location: Sec. 14, T1N, R41E

This site was on a small erosional remnant through which erosion had carved a tunnel. The resulting hole formed a small shelter which today is used as a playhouse by the children who live in the Peabody Coal Company's trailer court.

Several faint prehistoric petroglyphs, as well as more recent etchings, were carved into the wall near the shelter's entrance. Two panels contained prehistoric rock art (Fig. 11). Panel A (Fig. 11a) was 4 ft. above the ground surface and represented an apparently unfinished V-necked anthropomorph with a V-shaped line near one hand. Next to it was a recently drawn five-pointed star and the name "Carl Whitaker, Trapper, 1934." Mr. Whitaker still lives in Lame Deer, Montana, only 30 mi. away. Panel B (Fig. 11b) contained a circular shield-like object, unevenly dissected by five lines.

This site was tested for subsurface cultural deposits, but none were found.

24RB1024, Engineer Shelter

Location: Sec. 14, T1N, R41E

Site 24RB1024 was located in the sandstone rocks about 1/3 mi. north of the Dead Cow site, 24RB1005. The site was a very well hidden north-facing rockshelter. A single petroglyph of what appears to be a sheep or deer had been carved into the back wall (Fig. 12). The shelter area measured approximately 30 ft. long and 5 ft. deep. The height of the shelter's ceiling varied from 6 ft. at one end to 2 ft. at the other end. The soil within the shelter was aeolian-deposited sand and sandstone scalings that had sloughed off the ceiling.

The presence of the petroglyph on the back wall of the shelter prompted us to test the deposits composing the shelter floor. As at several other shelters, we found no cultural material on the ground surface. Because of a lack of space in which to work, we limited our test pit to a single 3 ft. square, 21 in. deep. Figure 13, a profile of the north wall of the test square, illustrates the stratigraphy in the

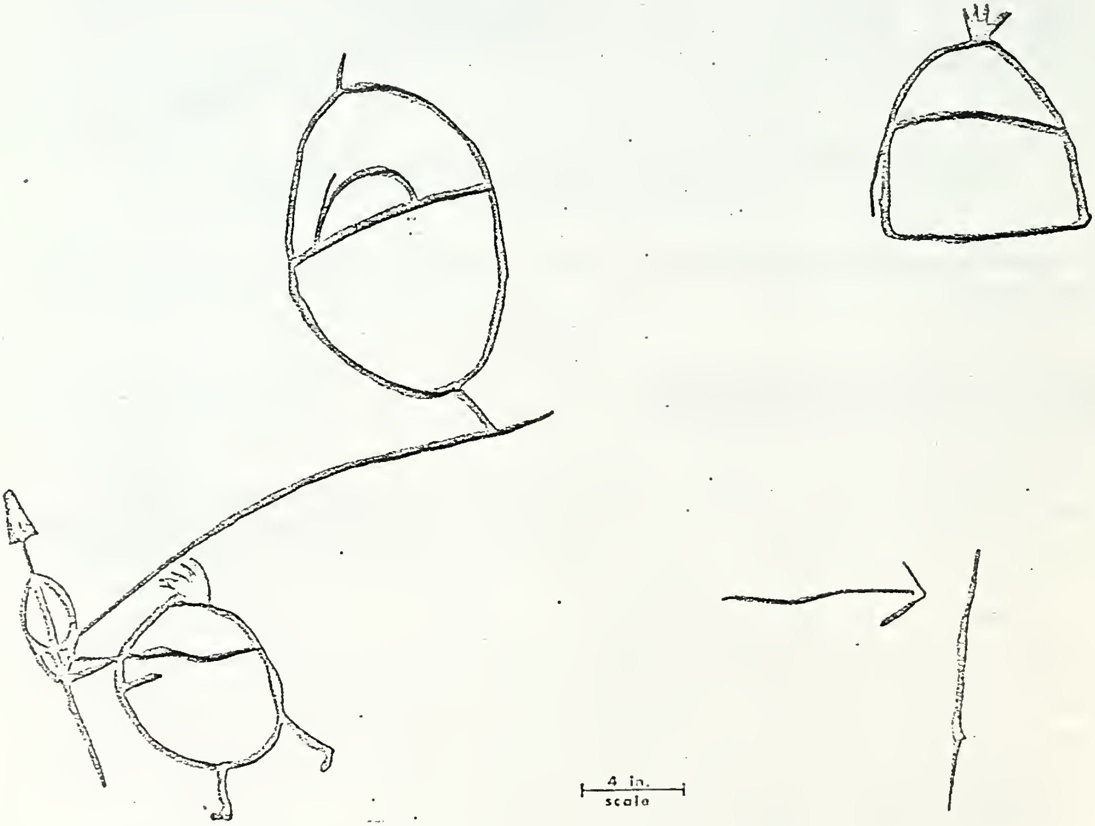

Fig. 9. Prehistoric petroglyph at 24RB1010, Tuma's Rock site.

floor deposits.

Level 1 was composed of loose aeolian-deposited sand mixed with chunks of sandstone sloughed from the shelter's ceiling. Lithic scrap material of gray porcelanite began to occur at the lower limits of this zone (at 2 to 4 in. below the surface.

Level 2 was a more compact mixture of sand, charcoal, and ash, resulting in a darker grayish-appearing soil. The level yielded numerous, rather large flakes of gray porcelanite throughout its depth.

Level 3 was compacted tan sand with some charcoal interspersed within it.

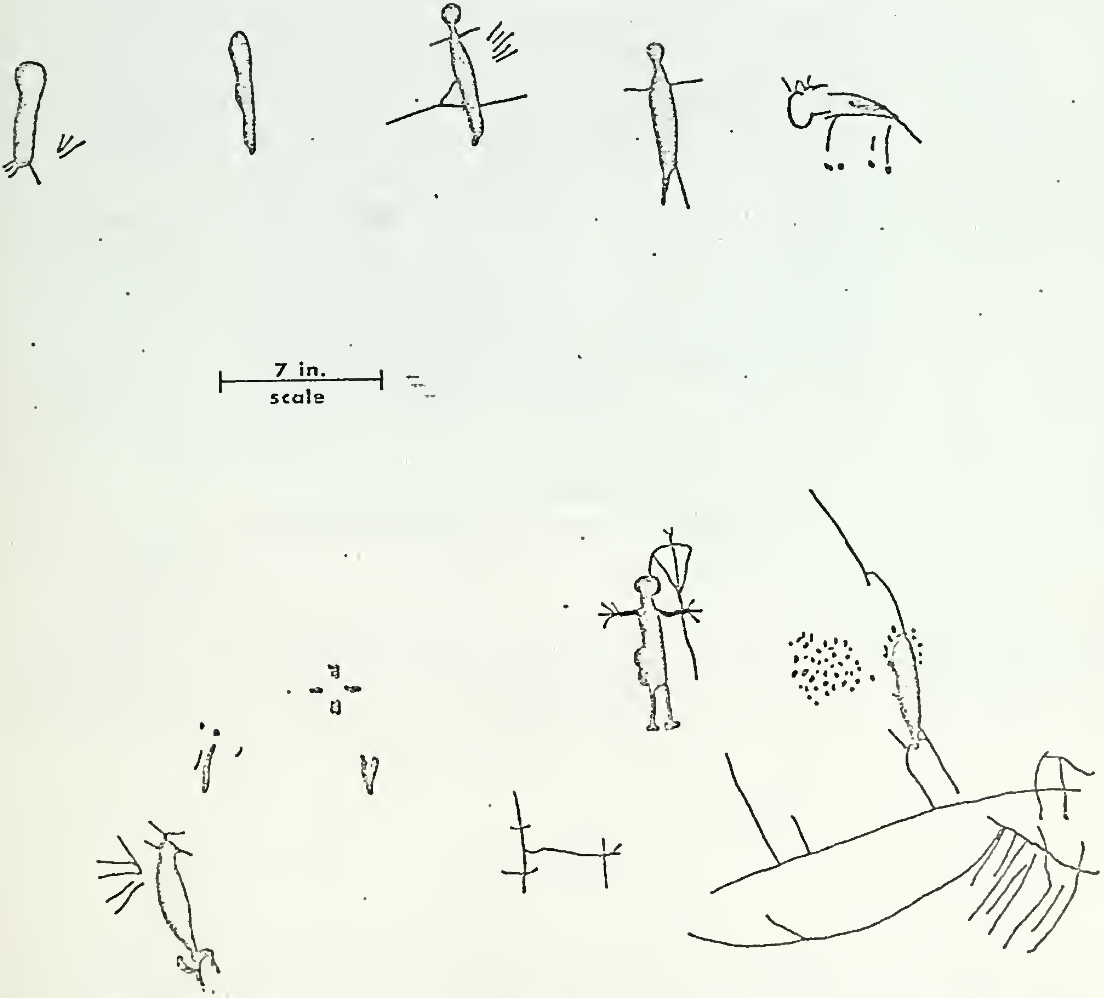

Fig. 10. Petroglyphs at 24RB1033, Lookout Point Petroglyphs site.

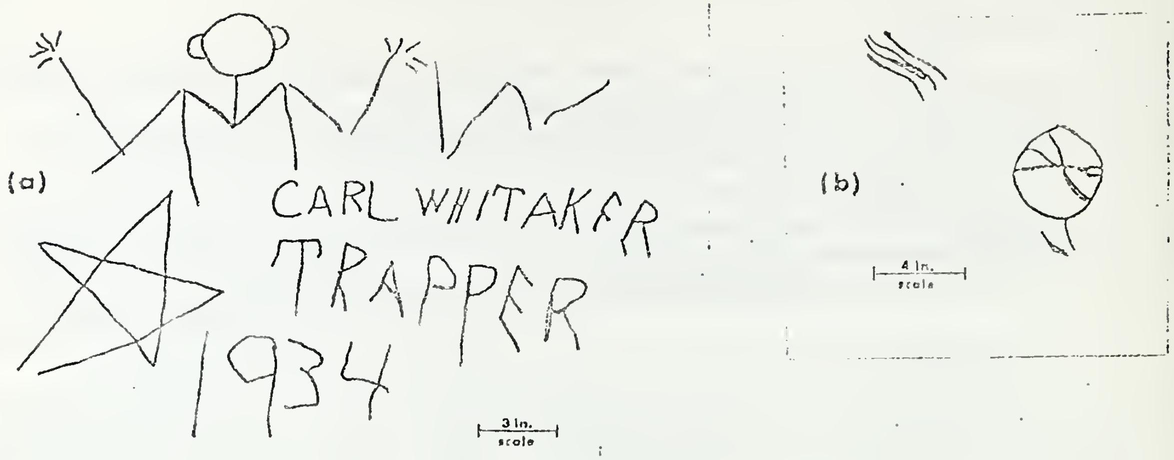

Fig. 11. Two petroglyph panels at 24RB1017, Trailer Court Cave site.

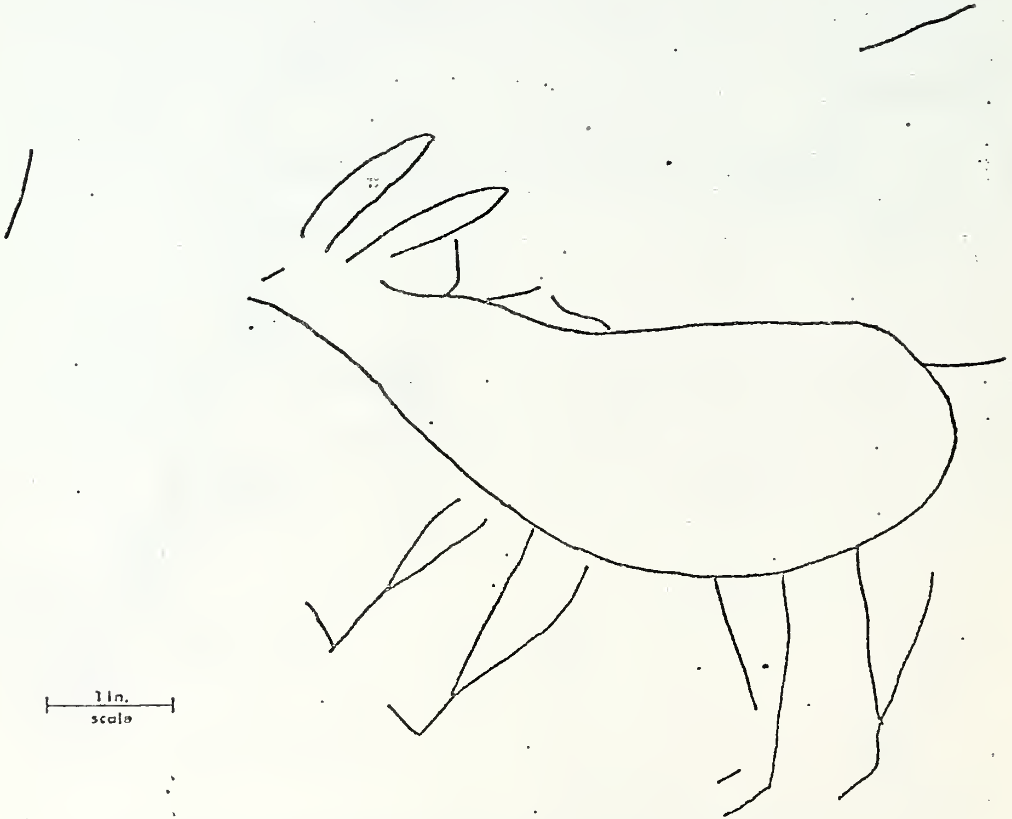

Fig. 12. Petroglyph at 24RB1024, Engineer Shelter.

This stratum extended from 6 in. below the surface in the northwest corner of the shelter to more than 11 in. below the surface in the northeast half of the test square. Large flakes of porcelanite similar to those present in Level 2 extended into Level 3 to a depth of 12 in. At 12 in. there was a reduction in flake size, with small flakes which appeared to be the product of tool-retouch activity becoming predominant.

Level 4 appeared in the northwest corner of the test square at 16 in. below the surface. It was a gray compact sand layer that dipped sharply toward the east. Flakes of lithic scrap material continued to be present in this zone. The trench was terminated at 21 in. below the surface, but we still had not penetrated completely through the cultural deposits.

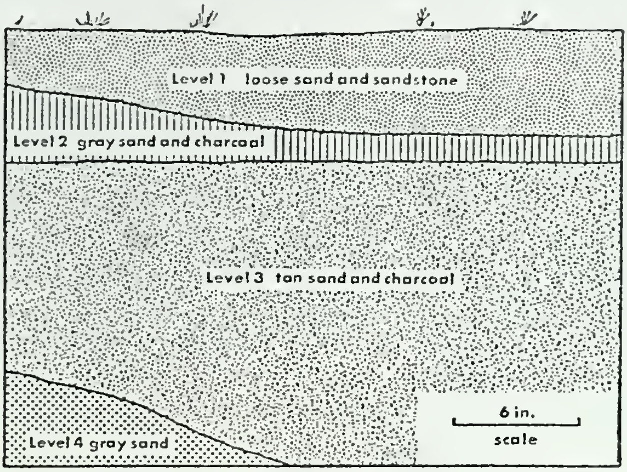
Level 1 loose sand and sandstone
Level 2 gray sand and charcoal
Level 3 tan sand and charcoal
Level 4 gray sand
6 in.
scale

Fig. 13. Profile of north wall of test excavation. 24RB1024, Engineer Shelter.

A date of A. D. 434 (516 B. P.) was obtained by obsidian hydration testing (by Leslie B. Davis, Montana State University) of a single spall of obsidian that was recovered from the test square in Level 2. This date should not be considered completely reliable since control on obsidian hydration dating is still not perfected.

Quarry Site

The predominant lithic material suitable for the making of stone tools in south central Montana is the red and gray porcelanite that appears on almost every ridge. Because it occurs in such abundance, one might question whether or not true quarrying was ever really necessary. Suitable material lay exposed on the surface within 100 to 200 yd. of each of our sites. At only one location did we see some indication of limited quarrying.

We define "quarry site" as a location from which cryptocrystalline rock was repeatedly obtained by prehistoric people and used for the manufacture of tools. Evidence for this utilization usually consists of pits which resulted from aboriginal mining, and an abundance of surface lithic detritus. Such surface debris (chips, spalls) resulted from the toolmaker pre-forming his lithic material into "blanks." These were later transported to habitation sites or other areas where they were made into usable tools.

24RB1006, Swift Wind Canyon Site

Location: Sec. 15, T1N, R41E

Site 24RB1006 was located along the base of one of the high sandstone ridges. We believe that it may have been a quarry area, and that it was possibly used by the inhabitants of 24RB1005, the Dead Cow site, since the two sites are in such close proximity. Large block fragments and spalls of porcelanite lay scattered over an area 100 yd. long, and extended 30 yd. up the side of the ridge.

Artifacts recovered: Several worked cores and large spalls were collected from the surface.

Site vegetation: Ponderosa pine, juniper, sage, native range grasses

Bison Kill Site

24RB1021, BLM Bison Trap

Location: Sec. 23, T1N, R41E

Site 24RB1021 was located approximately 100 yd. west of the Big Sky Mine tipple and 30 ft. from the haul road. The history of site 24RB1021 is one of continual damage. Originally discovered and collected from by Duke McRae, the ranch owner, this site was heavily looted by construction workers who camped nearby during the construction of State Highway 315. From that time on the site was intermittently dug into by amateurs until the development of the Big Sky Mine. Upon becoming aware of the site, Bureau of Land Management archaeologist, Lloyd Pearson, inspected it and recommended the site for excavation. After examining the site, we concurred with Pearson's recommendation on the basis of an abundance of bison bones in evidence on the ground surface in areas where amateurs had dug for arrowheads. Our crew completed excavation of an area 10 ft. by 30 ft. and from 8 to 14 in. deep during the 1971 field season. Work was continued during the summer of 1972 by a crew directed by Carolyn Ekland, graduate student in anthropology at the University of Montana. A complete report on the site and the results of the excavations is forthcoming from Ekland.

Rockshelters

An abundance of sandstone ridges in the survey area provided numerous rockshelters. Prehistoric people found such places to be suitable for use as living quarters: they can be cool in the summer, warm and protected from cold winds in the winter. However, some moisture probably entered the shelters from blowing snow or rain during severe storms. Although rockshelters are generally pleasant abodes in winter, the sun turns the south-facing shelters into small unbearable ovens at certain times of the day during the summer.

We found three rockshelters which contained evidence of prehistoric occupation: Colt 45 Shelter, Horse Shelter, and Engineer Shelter. The floors of shelters in this area are covered with aeolian-deposited sand, and rocks that have fallen from the shelters' ceilings. Neither Horse Shelter nor Engineer Shelter had any apparent natural soil stratigraphy; Colt 45 Shelter contained several disjointed gravel lenses. Uniform sands extended for at least 5 ft. below the surface at Horse Shelter, and into a whiter sand 4.5 ft. below the surface at Colt 45 Shelter. As the vertical profile (Fig. 18) indicates, it generally seems that evidences of human activity at the Colt 45 Shelter occurred in levels of mixed sand and charcoal. However, soil disturbance caused by rodents, and probably also by ungulates seeking shelter, has resulted in a confusion and mixing of the natural strata.

More recently, cattle have discovered the protection offered by these rockshelters, and a layer of compacted manure has effectively sealed the original sand layers. In order to establish whether or not a shelter had been occupied by humans, it was necessary to dig a test trench down through the dung.

24RB1011, Horse Shelter
Location: Sec. 27, T1N, R41E

Site 24RB1011 (Fig. 14) was a west-facing rockshelter located on the southwestern side of the sandstone outcrop at the western edge of the Big Sky Mine. The shelter area measured 51 ft. in length and was 14 to 15 ft. deep. The entire surface within the shelter was covered with as much as 6 in. of dry, compacted cow dung.

On the rear wall of the shelter several initials had been carved into the sandstone wall, together with an outline etching of a horse which may or may not be prehistoric in origin. Vegetation in the vicinity of the shelter consisted of cheatgrass, sage, rhus, and other native grasses.

No prehistoric remains were found on the ground surface, but a test square revealed the presence of a single level evidencing human occupation. Excavation was recommended and subsequently carried out (see excavations section of this

Fig. 14. 24RB1011, Horse Shelter. View looking east.

Fig. 15. 24RB1010, Tuma's Rock (left, center) and 24RB1012, Colt 45 Shelter (far right, center). View looking west.

report). No nearby water would have been available to the occupants of the shelter during the summer, but a small coulee 100 yd. to the south would probably have held water briefly during the spring run-off. Unfortunately, there was nothing in the excavated material to indicate the season of occupation.

24RB1012, Colt 45 Shelter
Location: Sec. 27, T1N, R41E

Site 24RB1012 (Fig. 15) was an east-facing shelter near the western edge of Peabody Coal Company's Big Sky Mine and 100 yd. north of the Horse Shelter site. The overhang of the shelter extended a maximum of 13 ft. and measured 15 ft. in length. As at Horse Shelter, the entire floor was covered with compacted cow dung up to 12 in. in depth. Adjacent to the shelter's floor area, rhus, cheatgrass, and other native grasses formed the surface vegetation. Stunted ponderosa pine and rhus were the primary plants growing on top of the sandstone outcropping from which the shelter was formed.

Our test trenches in Colt 45 Shelter revealed cultural deposits that extended for a depth of 40 in. below the surface. The shelter was recommended for excavation, and our subsequent activities there are described in the excavations section of this report.

The nearest water source for the occupants of this shelter would have been the same small coulee that runs by Horse Shelter and which probably contained water only in the early spring.

The Excavations

Four sites were excavated after testing indicated that significant subsurface cultural materials were present: Tuma's Rock (24RB1010), Horse Shelter (24RB1011), Colt 45 Shelter (24RB1012), and the BLM Bison Trap (24RB1021). The latter (24RB1021) will be reported by Carolyn Ekland after she completes further work. Horse Shelter, Colt 45 Shelter, and Tuma's Rock are discussed below.

Three of the sites excavated--Horse Shelter, Colt 45 Shelter, and Tuma's Rock--were located within 100 yd. of each other in Sec. 27, T1N, R41E in Rosebud County. The sites were situated on the end of a low sandstone ridge that projects southeastward into Miller Coulee. Other shelters, carved from the exposed Fort Union sandstone by erosional forces, primarily wind, are relatively abundant throughout the region. Vegetation on the ridges is primarily small ponderosa pine, juniper, sage, and native grasses. Rhus often occurs at the edges of the shelters.

At the time of occupation there was probably a small spring 50 yd. south of the shelters which would have provided water for the shelters' inhabitants. Today the nearest water sources are an intermittent stream, Miller Creek, which is 1/2 mi. to the north, and a nearby draw through which water flows briefly during the spring run-off.

Excavation Techniques

The technique used for maintaining control during the testing of the shelters was to establish a datum point on the shelter wall and to record all depths as below the datum, rather than below the surface as is customary in open sites. A taut string and a line level for recording measurements were used. The reasons for our using this technique are as follows:

1) Often the soil in a rockshelter was very soft and riddled with rodent holes, thus great care had to be taken in measuring from the surface because the soil tended to slough and change easily.

2) Shelters were generally small enough to use the string line method effectively, yet too small to use an alidade or transit.

3) The fixed datum established an accurate reference base for future excavations to tie into the original trench.

4) Arbitrary digging levels for vertical control were generally necessary due to the lack of evident natural stratigraphy, and consequently vertical control measured from an arbitrary stationary datum gave more accurate measurements.

Test trenches were always oriented north-south, and a complete horizontal planimetric map was drawn of the floor. Thus we were able to plot the test trench and relate it to all other features (Fig. 16).

Discussions of the excavations at the Horse and Colt 45 shelters have been combined in the following sections because the sites were similar in content, similar in structure, within 100 yd. of each other, and presented a series of occupations in time. A radiocarbon date of A.D. 335±120 (GX-2556) from Horse Shelter dates the occupation there as having occurred between that of Component I (A.D. 45±100) (GX-2557) and Component II (A.D. 710±100) (GX-2558) at Colt 45 Shelter. Also, both shelters appear to have been sites temporarily occupied by small groups of people, families perhaps, at certain time periods over the last 2000 years.

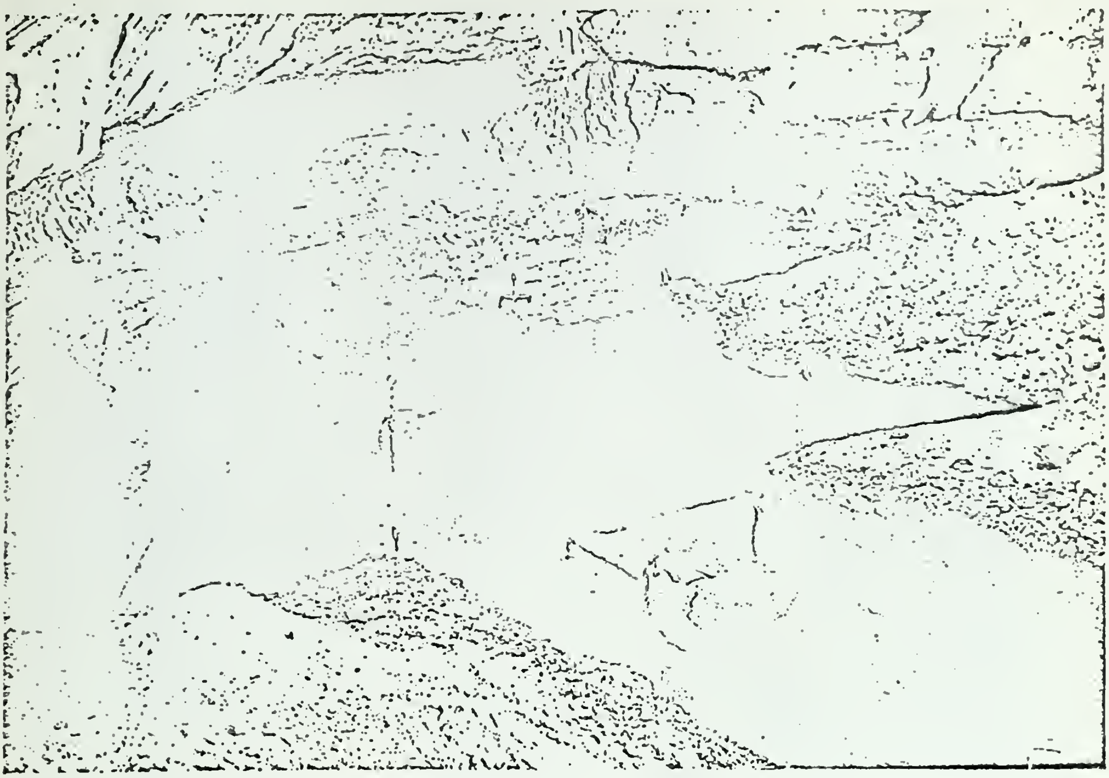

Fig. 16. Test trench at 24RB1011, Horse Shelter. View showing result of excavation techniques of arbitrary datum, and arbitrary vertical levels and horizontal grid system. Note cultural level appearing in wall at lower right.

Soil Profiles: Horse and Colt 45 Shelters

The following soil profiles (Figs. 17 and 18) were designed to show cultural relationships visible within the vertical walls of the test trenches in each shelter. That the soil in 24RB1012 was mixed and disturbed is obvious; the drawing makes the stratigraphy more clearly defined than it actually was. Only the deepest cultural level in Colt 45 Shelter, which we call Component I, was relatively consistent in soil color and texture. Small gravel lenses occurred throughout the depths of the site, but never followed continuously through the site's horizontal extent. And as is shown, often the gravel-sand mixture would just gradually change its proportion of sand to gravel. The gravel size was generally 0.3 to 0.5 cm. in dia.

Although Horse Shelter proved to be a single component site, Colt 45 Shelter contained three prehistoric components and one historic component. Occupation at the Colt 45 Shelter began in the late Middle Period (A.D. 20) and continued

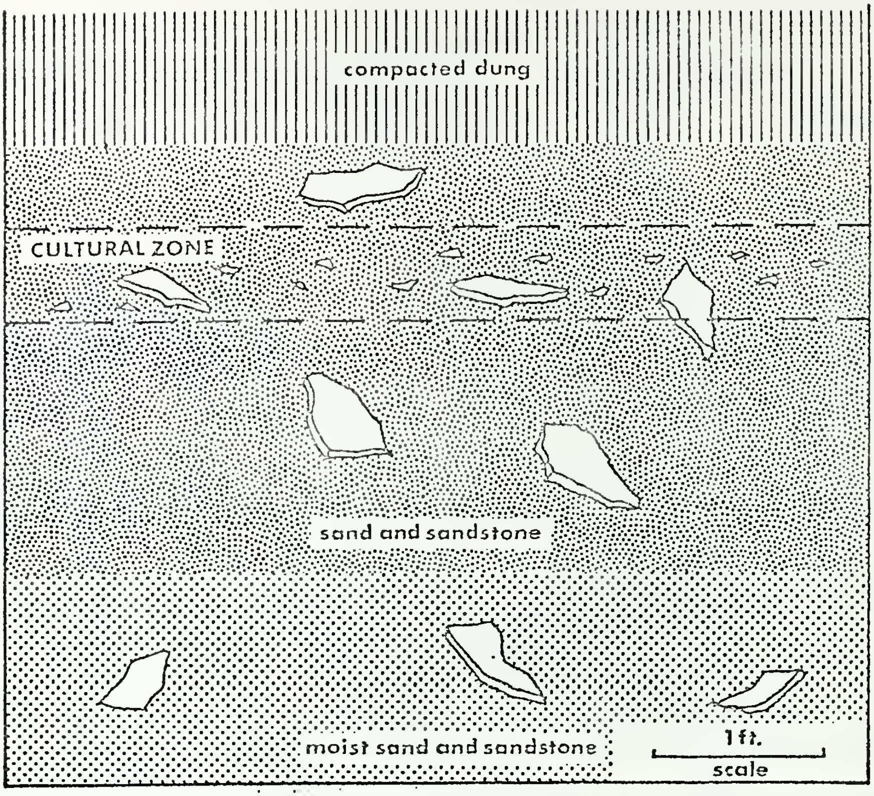

Fig. 17. Profile of north wall of test trench at 24RB1011, Horse Shelter.

to the time of white contact.

Soil and Pollen Analysis: Horse and Colt 45 Shelters

Inside the shelters the soil was composed of a mixture of sand, sandstone, and occasionally iron-bearing concretions from the decomposing sandstone of the shelter ceilings. The sandstone fragments varied from a few inches in diameter to 2 to 3 ft. slabs of varying thicknesses and widths. Wind-blown dust and sand had added to the soil which was loosely compacted due to constant rodent action.

A lack of definite stratigraphy in the deposits at both Horse Shelter and Colt 45 Shelter proved to be the most difficult obstacle in our attempts at cultural interpretation. It was apparent from our test excavations that, due to the uniform

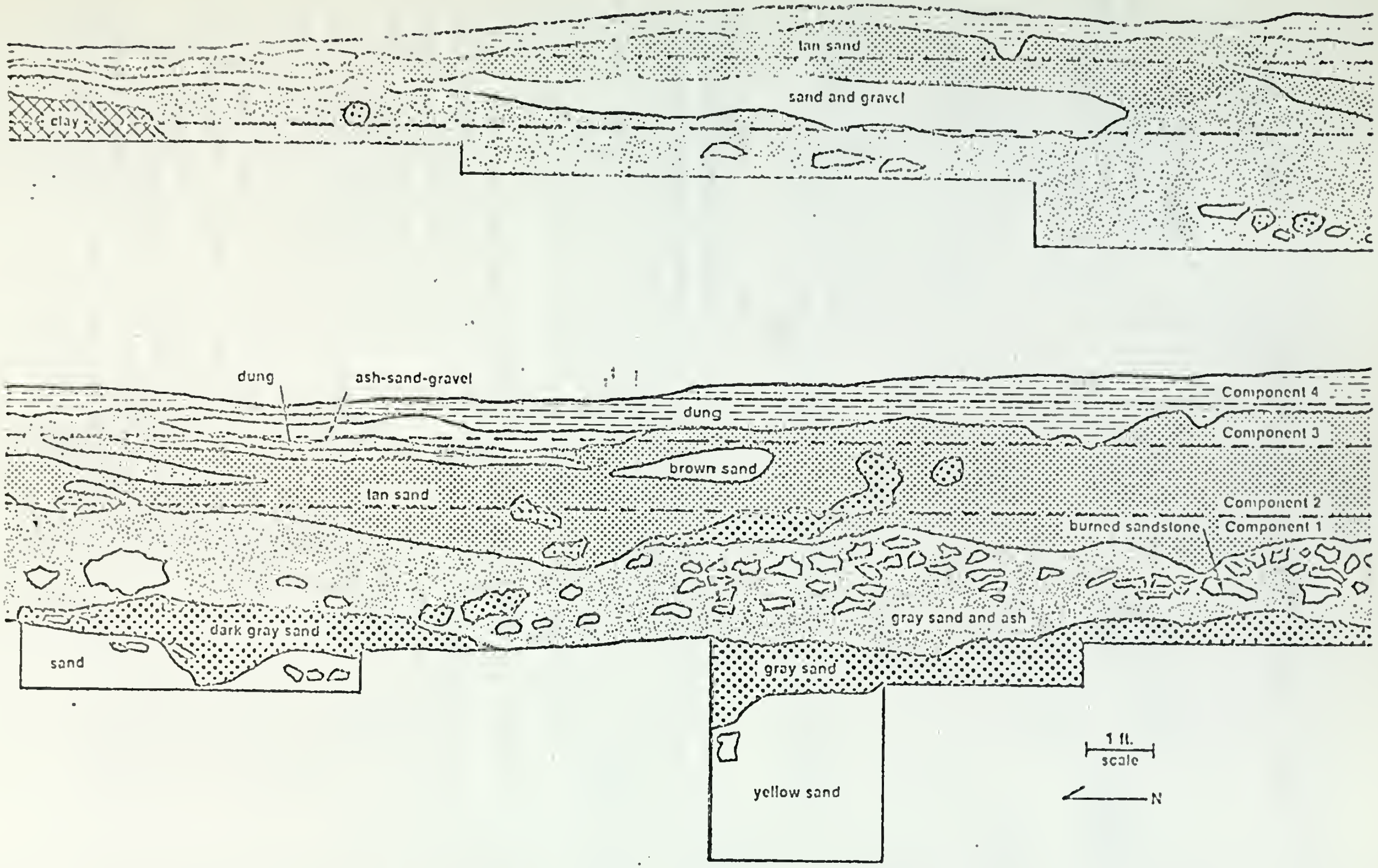

Fig. 18. Profile of north-south trench, east wall, 24RB1012 (Colt 45 Shelter); showing stratigraphy and vertical locations of components. Left end of bottom profile is continuation of right end of top profile.

TABLE 1

CHARACTERISTICS OF SOILS FROM COLT 45 SHELTER (24RB1012)*

Color	Depth	Characteristics
Dark yellow-brown to yellowish brown	1.0 in. - 2.5 in.	Loamy sand, slightly sticky, non-plastic, slightly effervescent
Light yellowish brown	2.5 in. - 4.5 in.	Sand, slightly sticky, slightly plastic, effervescent
Pale brown	5.5 in. - 10.5 in.	Loamy sand, slightly sticky, slightly plastic, effervescent
Yellow brown to grayish brown	10.5 in. - 25 in.	Loamy sand, slightly sticky, slightly plastic, charcoal present, highly effervescent

* (after Moody 1972:66)

color and texture in the soil, it was impossible to follow geological or "natural" stratigraphy.

Faced with this problem, we established 5 ft. squares as the major excavation units, and the cultural material from each 2 in. level within each 5 ft. square was separately bagged and labeled and then plotted into the grid system (Fig. 16).

Ula Moody, Washington State University Department of Anthropology, analyzed the soils and the pollen samples from 24RB1012. Her research is summarized in Tables 1 and 2. Although the pollen record was incomplete for the central portion of the soil column, Moody's research indicates a decrease in pine pollen after the third stratigraphic level and an increase in artemisia with soil depth. This increase would correlate with the two earliest components at the site.

Charcoal samples for radiocarbon dating were collected whenever possible, and flotation samples were collected and examined; however, no indications of macrobotanical remains or other items were found which gave any greater insight into the lifeways of the shelter's inhabitants.

TABLE 2

FLORA REPRESENTED BY POLLEN FROM SOIL COLUMN X, COLT 45 SHELTER (24RB1012)*

Helianthus	Chenopodeae
Gramineae	Polygeloceae
Yucca	High spine composite
Cirsium	Low spine composite
Pinus	Onagraceae
Sarcobatus	Juniperus
Artemisia	Rhus

* (after Moody 1972:49)

Features and Floor Plans: Horse and Colt 45 Shelters

The horizontal distribution of the features (feature here is defined as a specific assemblage of objects or an object which cannot be removed from the site), the artifacts, the chipping debris, and the shelter walls, rocks, etc. of each component in each site is shown in Figures 19, 20, 22, 23, 25, and 26. The floor plans provide a visual picture of the relationships of the in situ locations of the firehearths and artifacts, and their proximities to the shelter walls or other parts of the shelters.

All except one of the features found were firehearths. Radiocarbon dates established for charcoal from these firehearths provide the time sequence for the components of the sites.

Features of 24RB1011, Horse Shelter (Figs. 19 and 20)

Three features were found at Horse Shelter. Feature 1 was a burned log which lay against the wall inside the shelter and just under the layer of manure. This feature was omitted from Fig. 20 because it was not part of the cultural level and no other material was associated with it.

Feature 2 was a hearth which was defined by black soil and charcoal, and haphazardly surrounded by fire-burned rock. The area containing the charcoal measured 3 ft. by 1.5 ft. and was roughly oval in shape. Red soil, apparently the result of fire, was also associated with the hearth.

Feature 3 (Fig. 21) was a hearth filled with fire-burned sandstone. This

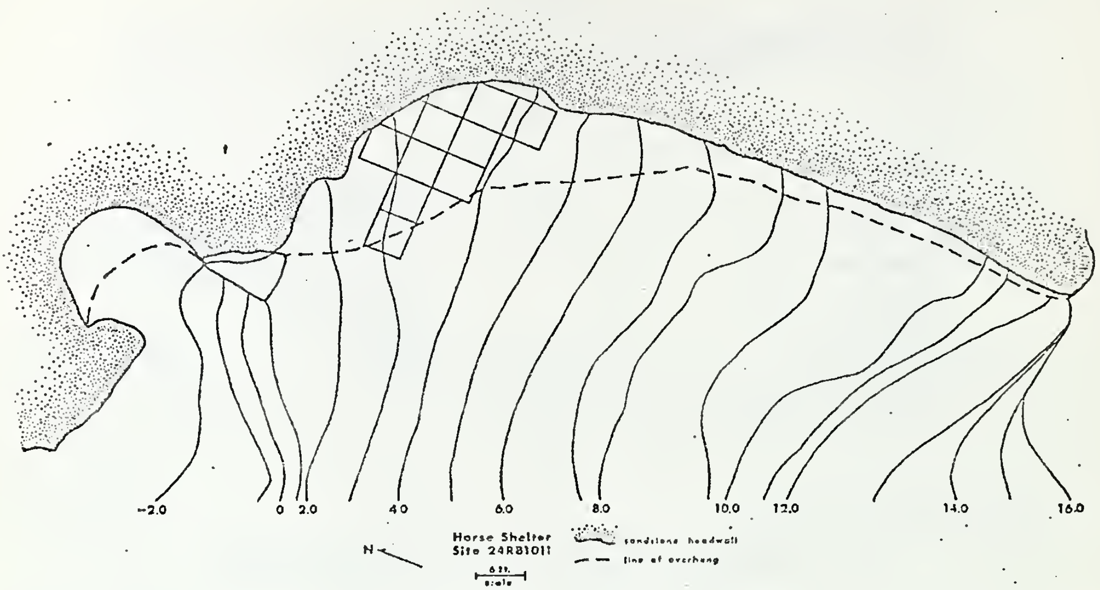

Fig. 19. Plan view of 24RB1011 (Horse Shelter), showing location of excavation units in relation to shelter walls and overhang.

hearth was circular in shape and measured 1.5 ft. in dia. Large chunks of charcoal were found among the sandstone rocks from a depth of 33 in. to 37 in. below the surface. The carbon sample collected for radiocarbon dating from this hearth yielded a date of 1645±120 B.P., or A.D. 335±120 (GX-2556).

Features of 24RB1012, Colt 45 Shelter

Component I (24 in. - 40 in. below the surface). From Component I at Colt 45 Shelter, the deepest cultural deposit at this site, two radiocarbon dates were obtained--1930±120 B.P., or A.D. 20±120 (GX-2559), and 1905±100 B.P., or A.D. 45±100 (GX-2557). The former date (A.D. 20±120) was obtained from charcoal collected from a wall-like rock structure (Fig. 22, [a]) that formed a small barrier separating the outside of the shelter from the interior shelter floor area. The second charcoal sample was taken from a small area of charcoal on the floor of the shelter. The latter area was not given a feature number, but is shown in the floor plan (Fig. 22, [b]).

Figure 22 illustrates the distribution of the cultural materials in Component I.

Feature 5 was a mass of rocks which at one time apparently formed either a wall or, more likely, a line of at least five rock piles. Five large concentrations

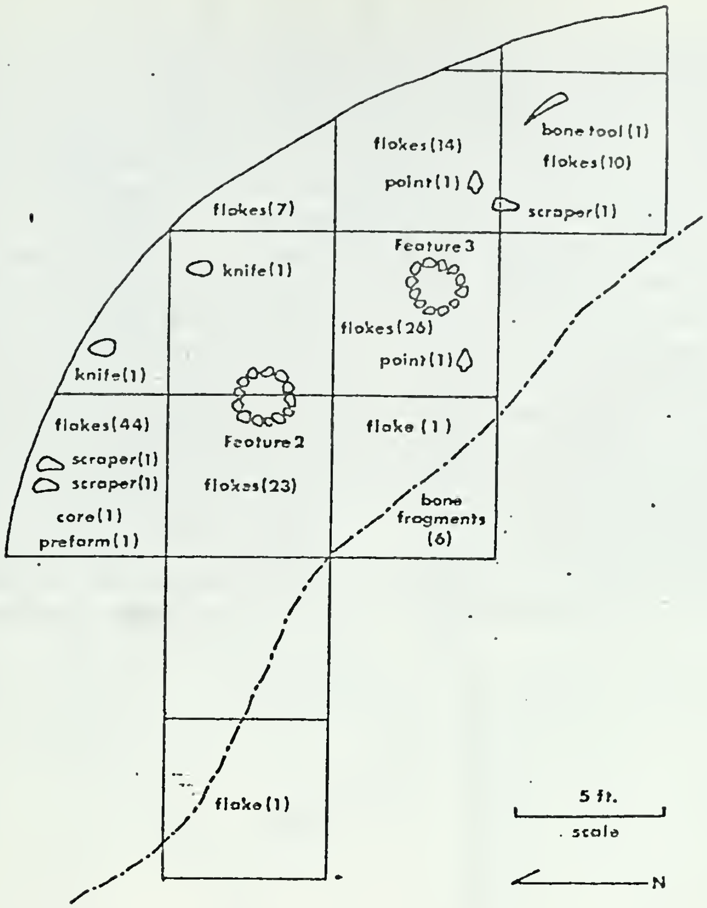

Fig. 20. Floor plan of excavated portion of cultural level at 24RB1011 (Horse Shelter), showing distribution of features, artifacts, and lithic debris. See Fig. 19 for location of excavated area in relation to shelter.

of rock, each roughly 2 ft. to 3 ft. in dia., seemed to have been placed in a line. If these were indeed rock piles, then each pile must have been at least 12 in. in height. Between each of the rock concentrations were found large quantities of fire-burned rock which were probably originally part of the five piles. Flakes from tool manufacture were scattered throughout the rocks and on either side of the line of rock piles. However, finished tools were recovered only from either side of the wall. Possibly this rock mass was used as a type of fire reflector for heating the southern side of the shelter, or it may have been a fortification of sorts. The soil in which the rocks lay was composed of powdery charcoal and sand (see Fig. 17).

Component II (12 in. - 24 in. below the surface); Fig. 23. More features (five, all firehearths) were found in Component II at the Colt 45 Shelter than in any other of the site's components. This indicates perhaps that more small groups utilized the shelter during this time period than during any other period represented at the site. Also, for the first and only time in the history of the site, the north portion of the shelter was used during this period. As was true in the other components, the area of heaviest use was in the central part of the shelter, as indicated by the distribution of artifacts. However, most of the hearths were located toward the edges of the shelter. The one sample from this level taken for radiocarbon dat-was from a small area of charcoal and fire-burned earth that lay beneath a large boulder. The sample was dated at 1240±100 B. P., or A. D. 710±100 (GX-2558).

Feature 2 (Fig. 24a) was a small firehearth 10 in. in dia. and 3 in. thick from the top of the highest rock to the bottom of the lowest. The fire bed was a shallow pit beginning at 19 in. below the surface and extending to 22 in. below the surface. The hearth was composed of nine rocks that had been laid in a random position inside the pit. No artifacts were found in association with the hearth.

Feature 3 was a small lens of fire-burned earth and charcoal which partially extended into an unexcavated wall and under a large sandstone boulder that had

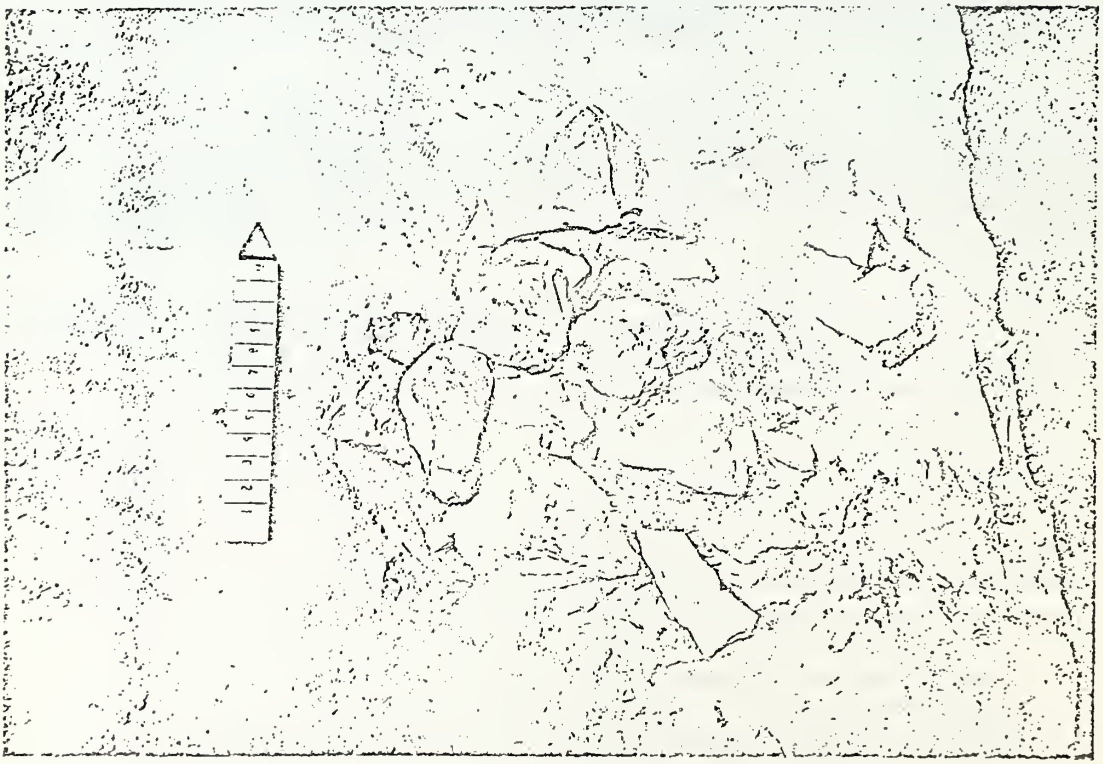

Fig. 21. Firehearth (Feature 3) at 24RB1011, Horse Shelter.

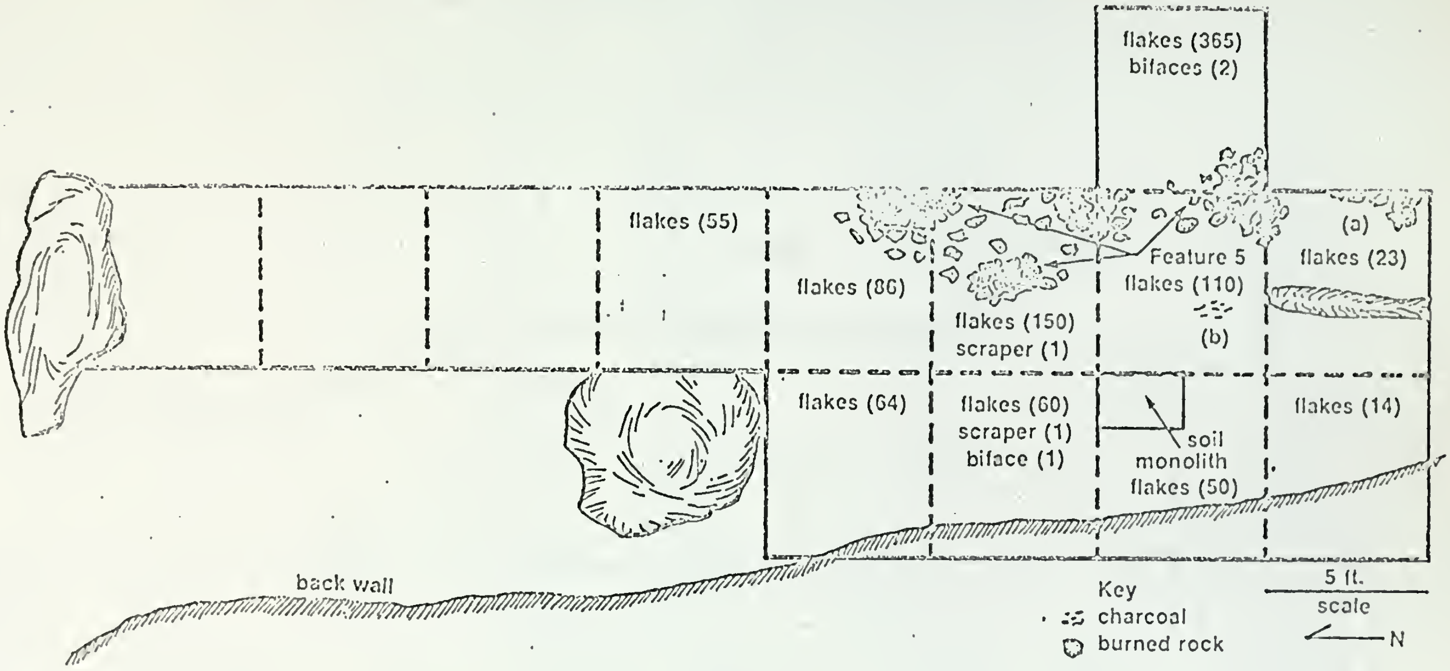

Fig. 22. Floor plan of Component I, 24RB1012, Colt 45 Shelter.

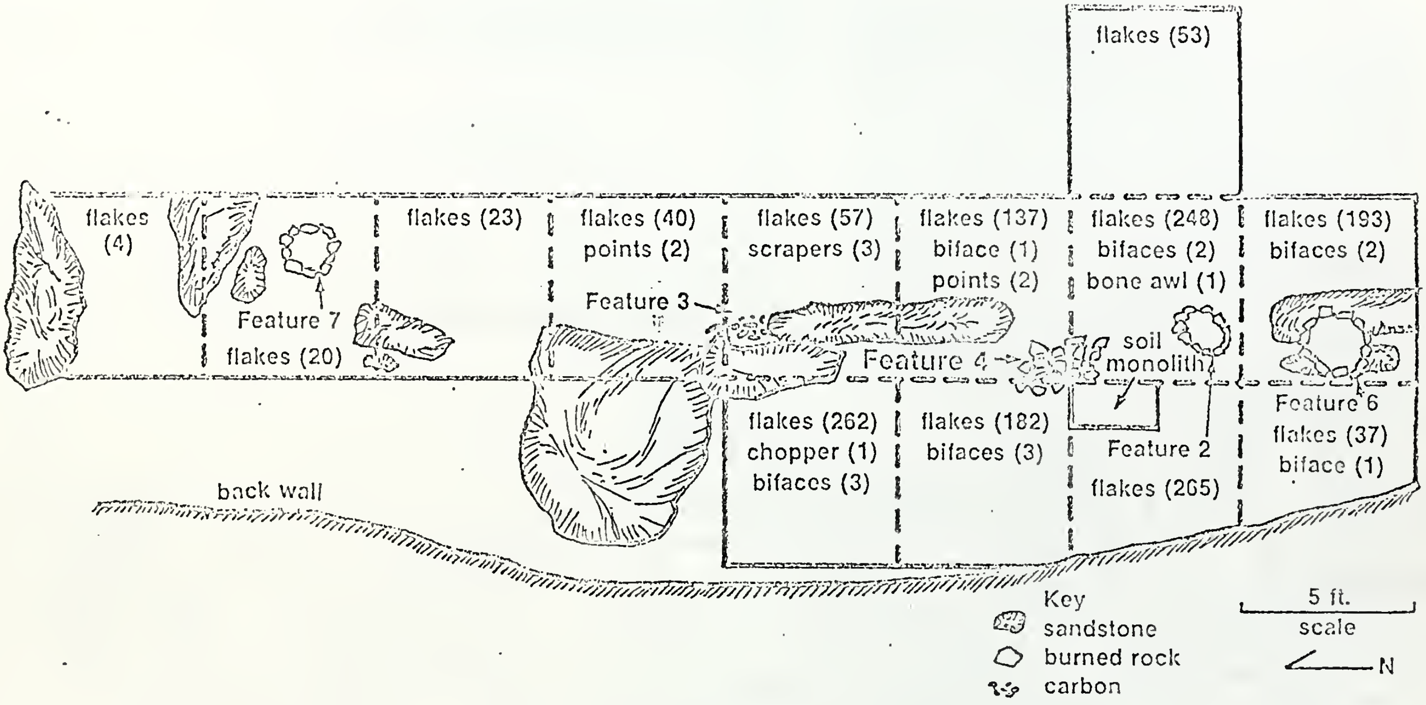

Fig. 23. Floor plan of Component II, 24RB1012, Colt 45 Shelter.

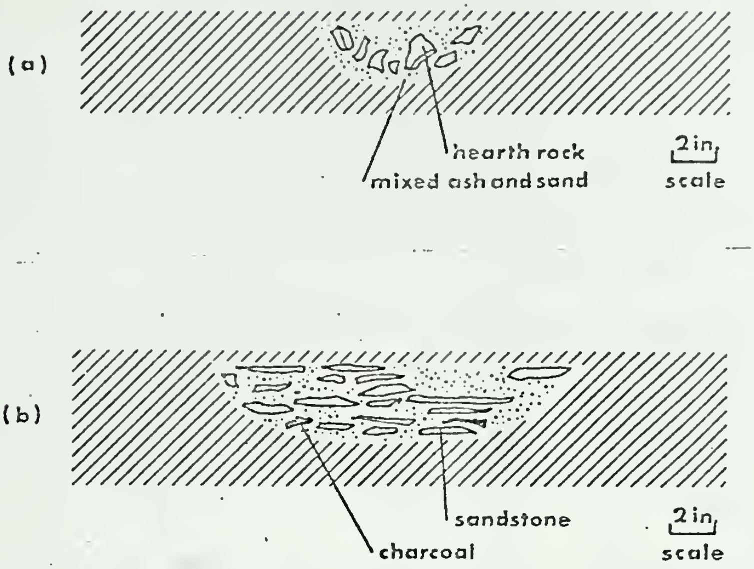

Fig. 24. Profiles of firehearths, Component II, 24RB1012 (Colt 45 Shelter). a, Feature 2; b, Feature 7.

fallen from the north end of the shelter's ceiling. Feature 3 first appeared 16 in. below the surface and extended to 20 in. below the surface. No artifacts or lithic debris was found in the charcoal lens itself.

Feature 4 was an amorphous bed of rocks that was concentrated in an area approximately 24 in. in dia. in the north end of the shelter. The feature began about 20 in. below the surface and extended into the top of Component I in one area. Maximum depth of the rock bed was 28 in. The purpose or function of this strange mass of rocks is not known. Most of the rock was thoroughly burned, and numerous scrap flakes and several artifacts lay within and on the edges of the rock bed. It could not be determined whether this feature may have been part of the rock piles, or "wall-like mass," which compose Feature 5 in Component I.

Feature 6 was a large, approximately 16 in. in dia., pile of fire-burned sandstone rocks of which 50 were over 2 in. in dia. and about 25 of which were less than 2 in. in dia. It appeared as if the rocks had been deliberately placed between and on top of two large sandstone blocks that had fallen from the roof of the shelter. There was no apparent organization to the distribution of the rocks, and the charcoal found throughout this feature was not concentrated in any particular place. The first evidence of this hearth appeared at 15.5 in. below the surface, and the rocks extended another 4 to 5 in. in depth.

Feature 7 (Fig. 24b) was a firehearth composed of 40 flat sandstone rocks. It lay 19 to 25 in. below the surface, and measured about 6 in. thick and 18 in. in dia. An interesting characteristic of this hearth was that all 40 of the rocks that had been piled into the shallow pit lay flat and almost parallel to the living surface. The rocks looked almost as if they had been chosen for their shape. The fact that this hearth was located away from the main living area of the shelter may also be of significance. A few sharpening flakes (flakes less than 0.75 cm. in length) were found within the hearth itself and within this excavation unit, and a pyriform knife lay nearby. Although charcoal was collected for radiocarbon dating, not enough was recovered for an adequate sample.

Component III (6 in. - 12 in. below the surface). Component III contained numerous projectile points and tools, but no firehearths or other features (Fig. 25). Also, there was very little bone in this level. It seems probable that Component III was occupied only briefly. Some charcoal stains were present in this component, but because of disturbance by rodents, it was impossible to ascertain whether the charcoal was in situ or intrusive.

Component IV (0 - 6 in. below the surface); Fig. 26. Component IV was the historic-aged level of the shelter. The soil in this component consisted of loamy sand and cattle manure. The radiocarbon date obtained from Feature 1 in Component IV indicates that the latest occupation of this site occurred within the last 200 years. This recent date is supported by the recovery from this component of historic artifacts--canvas cloth, and metal buttons and rivets. In addition, two .45 caliber Colt cartridges, after which the site is named, lay 10 ft. from the location where the cloth and most of the buttons were found. A single projectile point recovered from this component is probably intrusive from Component III; it was found just above the projectile points from Component III in an area that had been disturbed by rodents.

Feature 1 was a layer of compacted red sand which appeared to have been discolored as the result of fire. This feature was oval in shape and measured 6 to 7 ft. by 1 to 2 ft. Charcoal extended outward from one end of the feature another 2 ft. The depth of the feature was 2 ft. 5 in. below the surface. Charcoal was abundant under parts of Feature 1 and around its edges. The charcoal was very clean and powdery under the sand, which is rather unlike that which would have resulted from a fire fueled by wood. Charocal flakes 1/2 to 1 in. in dimension were found at the edge of the red sand and were taken as a charcoal sample. The date established for these charcoal flakes was less than 200 years ago (GX-2561).

Faunal Remains: Horse and Colt 45 Shelters

Faunal remains, although present in almost every level of each 5 ft.

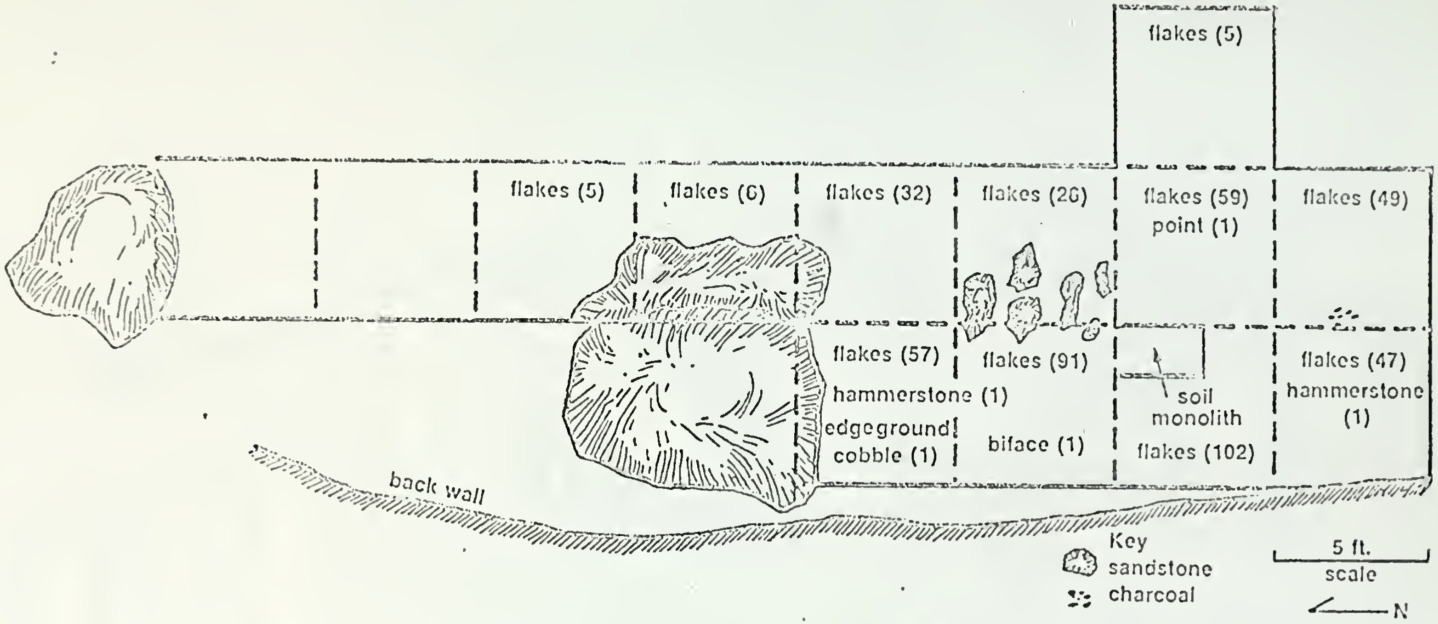

Fig. 25. Floor plan of Component III, 24RB1012, Colt 45 Shelter.

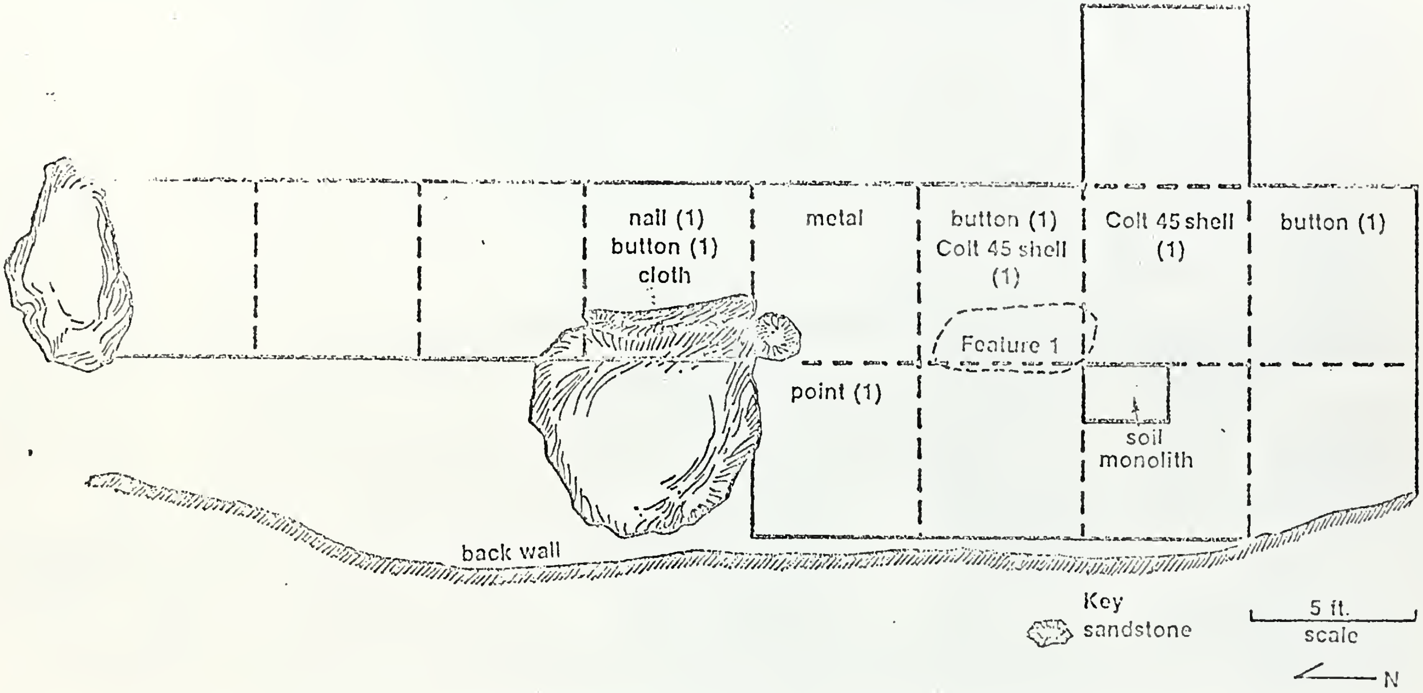

Fig. 26. Floor plan of Component IV, 24RB1012, Colt 45 Shelter.

excavation unit, were generally badly fragmented and poorly preserved. Consequently, much of the bone material could not be identified. Identifiable bone (identified with the aid of Philip Wright, Department of Zoology, University of Montana) indicated that the following animals were utilized by the occupants of both shelters:

Antelope	(Antilocapra americana) (both mature and immature)
Bison	(Bison bison)
Mule deer	(Odocoileus hemionus)
Grouse	(Pedioecetes)
White-tailed jackrabbit	(Lepus townsendi)
Prairie dog	(Cynomys)
Ground squirrel	(Citellus lateralis)
Pocket gopher	(probably Thomomys)
Toad	(Buffo)

As anticipated, the faunal remains recovered from the two sites represent most of the major ungulates known to have inhabited the region. Noticeably absent are elk and sheep, but this absence seems also to occur at other sites that were occupied within this same span of time. It may be significant that the inhabitants used no particular ungulate species to the exclusion of others. Rather, the bones of the various ungulates appeared to be present in relatively equal amounts in each component (Table 3). Only in Component III at the Colt 45 Shelter was there no bison represented; however, there was an apparently limited occupation of the site at this time also.

In Table 3 the faunal remains are listed according to the component at Colt 45 Shelter from which they were recovered, and the number of excavation units within each component within which they were found. Because of the fragmentation and the limited number of identifiable bones recovered, no attempt was made to reconstruct the number of individuals of each species represented. However, an indication of the number of 5 ft. squares in which the identifiable fragments were found might allow the reader to derive a better understanding of the distribution of the faunal remains.

The distribution of bone within the various components was generally similar to that of the lithic scrap flakes. For instance, in Component III at the Colt 45 Shelter, both the concentrations of flakes and the concentrations of bones were located in the front, or open, side of the shelter.

The only immature animal represented in the assemblage of faunal remains was from Component IV at the Colt 45 Shelter. The presence of bones from a young antelope in this level would indicate that the animal was probably brought to the site in the springtime. Based on the absence of immature bones in the earlier components at Colt 45 Shelter and at Horse Shelter, one might speculate that those occupations occurred during winter or very early spring. However, the evidence is not conclusive.

TABLE 3

DISTRIBUTION OF FAUNAL REMAINS: 24RB1012, COLT 45 SHELTER

	Number of excavation units in which represented
Component I	
Antelope	4
Deer	4
Bison	2
Small rodents	4
Rabbits	2
Grouse	1
Frog or toad	1
Component II	
Antelope	3
Deer	6
Bison	3
Rabbit	2
Small rodents	2
Small bird (robin-sized)	1
Component III	
Deer	2
Antelope or deer	1
Rabbit	1
Ground squirrel	1
Component IV	
Deer	2
Bison	2
Antelope (immature)	1
Small rodent	1
Grouse	1

24RB1010, Tuma's Rock Site

Test excavation of site 24RB1010 yielded two projectile points, some burned bone fragments, and some lithic scrap material resulting from tool manufacture. Subsequent, full-scale excavation produced no additional cultural material, however. This might be explained by the presence of large, slightly subsurface blocks of sandstone at the site which would have eliminated the possibility of a level floor suitable for occupation.

The projectile points recovered are small side-notched points typical of Late Prehistoric Period sites in the Northwestern Plains and similar to those recovered from Component III at the nearby Colt 45 Shelter (24RB1012). In all probability site 24RB1010 was used occasionally by the occupants of either Horse Shelter or Colt 45 Shelter, since both are within 100 yd. of this site.

The Artifacts

APPENDIX #9

INTERIM EFFLUENT GUIDANCE

By

U. S. Environmental Protection Agency

INTERIM EFFLUENT GUIDANCE
FOR NPDES PERMITS

OFFICE OF PERMIT PROGRAMS
U. S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D. C. 20460

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

1 MAY 1973

OFFICE OF
ENFORCEMENT AND GENERAL COUNSEL

MEMORANDUM

TO : All Regional Permit Program Directors

FROM : Office of Permit Programs, Washington, D. C.

SUBJECT : Updated Effluent Guidance Materials

The attached guidance package consists of two parts:

1. Instruction and limitations which apply to permit applications in all industrial categories. In general this is the guidance you received in our January 2, 1973, memorandum; there have been some additions and deletions.

2. Updated and streamlined guidance documents in a standardized format, to replace the guidance documents which you received at intervals since June 1972. Previous effluent guidance documents are superceded. Explanatory data and references have been deleted and will be made available in separate back-up documents. Sampling and monitoring instructions also have been deleted. Specific guidance for monitoring and self reporting has been provided in draft form 3/9/73.

The Effluent Guidelines Division, Office of Air and Water Programs and the Permit Program Staff, Office of Enforcement and General Counsel, have reviewed the effluent guidance documents and have concurred in the technical applicability of these documents for interim use in the issuance of permits under Section 402, until effluent guidelines are promulgated under Section 304, but only within the limitations set forth in the Deputy Administrator's memo of February 28, 1973, which has been cited in each case in the guidance under the title "Application of Limitations".

As pointed out in our memo of January 2, 1973, this guidance applies primarily to major or significant dischargers. Considerable care and discretion must be used in the application of this guidance to minor or less significant discharges.

There may be individual cases outside the areas indicated below where a determination of best practicable control technology currently available for the industrial facility in question can be made with a high degree of confidence, through reliance on the interim effluent guidance together with an evaluation of the particular conditions in existence at the facility. Decisions to issue permits in such cases should be made with caution and on a limited basis. Subject to the foregoing, the following guidance documents may be used in accordance with the caveats and qualifications cited.

Robert B. Schaffer

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General Effluent Guidance for All Industrial Categories

The following guidance on special technical considerations in the application of limitations, and on effluent limitations for specific parameters, is to be used as appropriate in writing permits for applications in all industrial categories.

General

The guidance documents were developed to cover, as specifically as possible, the identified industrial categories. The numbers previously developed and the information contained herein were meant to apply generally to the industrial category but more specifically to "major", "large", or more significant dischargers. Additional information on other considerations (i.e., economic, age) will be forthcoming. This should not materially effect your priorities. However, should a problem arise that requires additional consideration, please contact the appropriate headquarters individual. You will find, as you probably already have, that the guidance does not lend itself to all situations involving "special" problems of age and economic impact, etc., for a given category.

pH

The normal range in which all discharges should fall is generally accepted to be between a pH of 6 and a pH of 9. Any discharge outside of this range should be well justified and should consider such things as the addition of total dissolved solids from neutralization and the buffering capacity of the receiving water. If the pH of the discharge is significantly different than the pH of the receiving water within the 6.0 to 9.0 range and the discharge is a significant portion of the receiving water, toxic effects due to pH fluctuations within this range can be shown. Therefore, it is imperative that the discharge be evaluated carefully even within the range of 6.0 to 9.0, (e.g., 7.0 ± 0.5).

Coliform

This is a significant parameter for mixtures of industrial wastewater and sewage and may be significant for certain industrial wastewaters alone. Because of the sewering of most plants, the absence of sewage should be established by dye test. If sewage is present, the following effluent limit should be imposed:

> "Organisms isolated in the fecal coliform test shall not exceed 1000 organisms per 100 ml."

Total Dissolved Solids

Total dissolved solids have not been limited in the individual guidance documents. There is technology available for the removal of total dissolved solids when receiving water quality so dictates.

Oil and Grease

Permit conditions for petroleum-based Oil and Grease, based on the Standard Methods (13th Edition, Method 137) are to reflect an achievable concentration of 10 mg/l as the basis for determining limitations.

This limitation should be imposed where appropriate across industrial categories. If petroleum-based oil and grease is not present in the characteristic discharge, the limitation may be eliminated. Oil and grease analysis may also be used to detect oily materials of animal and vegetable origin. The limitation of oil and grease in these instances should be applied with caution. Vegetable or animal based oil and grease is generally less significant than petroleum based oil and grease at the same levels.

Toxicity

National standards for toxicity limitations via bioassay procedures have not been set. Certain States require bioassay procedures which will be incorporated in our discharge permits when those states include the requirement as part of certification under Section 401. A list of toxic substances and standards will be promulgated under Section 307 of the Act.

Heavy Metals

A general limitation of 1 mg/l maximum total dissolved heavy metals should not be imposed across the board. The figure is, however a good point of reference when establishing limits for a discharge involving a number of dissolved heavy metals which could present a hazard to water quality due to synergistic toxic effects.

Utility Discharges, Thermal Energy

For practical purposes, thermal limitations are most significant when applied to once through non-process contact cooling water, and treated effluent. This includes both manufacturing industry and power generating industry.

The industrial effluent limitation guidance addresses "process wastewaters" only, which have come into intimate contact with raw material, products, byproducts, etc., and include all wastewaters containing significant amounts of non-thermal pollutants. Typically, these streams require biological or physical treatment to reduce the content of specific constituents. When the resulting "treated effluent" contains thermal energy, additional considerations and limitations may be necessary.

Included in this definition of "process wastewaters" are cooling tower blowdown, boiler water blowdown, water treatment plant backwashings and once through process contact (e.g., barometric condenser) cooling water. However, limitations to be applied to constituents of these components of "process waters" are generally not contained in existing guidance.

Relative to pollutant reduction in utility water components of "process wastewaters", each case should be evaluated individually. Further definition of "best practicable control technology currently available" in this area has been undertaken by contract studies under Effluent Guidelines Division of Office of Water Programs.

The combination of cooling water and treated process water effluent prior to introduction into the receiving water is permissible. In instances where monitoring of the combined flows will not provide adequate information because of a concentration below a detectable limit, monitoring may be required prior to the combination of process flows and non-contact cooling water flows. Where once through non-contact cooling water is collected with process wastewaters in combined sewers, no allowance may be given that would condone the dilution of the plant raw waste load and result in a higher pollutant discharges allowance.

Once-through cooling water that does not come into contact with process material (shell and tube heat exchangers) discharging into segregated sewers may be excluded from the accounting of pollutants (excepting thermal) limited in the permit where source of water is the receiving stream. In such cases, thermal considerations should be applied taking into account applicable Water Quality Standards and using the guidance afforded in the Thermal Technical Manual forwarded earlier in draft form. Monitoring for possible contamination should be required, especially where saline cooling water is used. Due to the corrosive properties of saline water, corrosion products may be significant. The logic for excluding once through non-contact cooling water from pollutant limitation accounting is based upon net/gross considerations relative to influent constituents, and upon the 'practicability' of treatment to reduce very low pollutant levels":

Typically large quantities of water relative to process leakage result in concentrations not appreciably higher than supply water characteristics, and so low as to produce dubious analytical results.

Unless a specific violation of Water Quality Standards results, such low concentrations would not ordinarily be expected to have a significant or adverse impact on the receiving water.

In the absence of adverse impact (i.e., violation of Water Quality Standards) on the receiving water, the benefit of treating such large quantities of water (especially for net pollutant reduction) does not justify the cost.

Color

Color is generally an aesthetic problem. Where a specific problem is evident, limitations may be set on a case-by-case basis based upon receiving water quality.

Net and Gross

Generally a discharger is not responsible for pollutants entering with his water supply if he takes water from the same source into which he is discharging. If his source is other than the receiving stream, he is to be charged with the gross discharge.

Unless industry specifically requests application of net considerations in writing, or unless the difference between net and gross is of major significance to a discharger, the permit should be written on a gross basis with no stipulation for influent values. Where the differences between net and gross application of effluent guidance is of relatively minor significance but industry requests application of net values, the supply water waste loading should be stipulated based on presentation of existing data (i.e., adjust limitation accordingly and write permit in gross terms.) Limitations that are established for materials that are normally expected to be "concentration controlled" (e.g., TSS and BOD) may not need total credit for influent levels (a well designed clarifier will generally produce a quality effluent - 20 mg/l ss - regardless of source of suspended solids). Where application of net values is of great significance to the dischargers, permit requirements for sampling the influent wasteloadings must be included.

Pollutants that are removed in the treatment of water in an industrial facility (e.g., silt removal, filter backwash) may not be returned to the receiving water. Once a pollutant is removed by the discharger it may not be reintroduced. In this situation net/gross considerations will be applied downstream of any pretreatment steps.

Disposal of Pollutants into Wells

If an applicant for a permit proposes to dispose of pollutants into wells as part of a program to meet the proposed terms of a permit, additional terms and conditions should be specified in the permit which either prohibit the proposed disposal or control the disposal so as to prevent pollution of ground and surface waters and to protect the public health and welfare. The Administrator's decision statement number five, February 6, 1973, "Environmental Protection Agency Policy on Subsurface Emplacement of Fluids by Well Injection" should be consulted and complied with.

Standard Conditions

The provided standard permit conditions will be included in each permit in the order and language given. Additional conditions necessary to meet state certification requirements will follow the standard special conditions in the permit. State requirements which exceed national requirements will generally be adopted for National Pollutant Discharge Elimination System permits written for discharges in the State. Please note, however, that only those State requirements included in the certification (Sec. 401 of the Act) must be adopted. Recommendations can be accepted for cause. In this manner, terms and conditions of dubious legal or technical validity, or that would tend to impede enforcement may possibly be screened out.

Limitations

Permits are to be written with limitations in terms of kilograms (pounds) of each pollutant per day excepting in certain industries (such as mining operations and utility discharges) where wastewater generation is not related to production levels. The monthly operating average effluent limitation, in kilograms (pounds) per day, should be calculated using the production basis multiplied by the appropriate effluent level as specified in the guidance. It is not our intent to specifically limit water use in the permit unless the flow is so high as to cause a scouring problem in the receiving water. Once a permit has been issued based on the use of effluent volume, production levels, and attainable abatement technology, the discharger may meet his requirement via any combination of effluent volume and concentration providing he does not violate water quality standards in so doing. If a discharger drastically reduces his water usage he may augment receiving water diffusion capacity to prevent localized toxic effects or take advantage of improved treatability to reduce pollutant discharge, at his option, within the life of the permit.

The basis for limitations shall be:

1. Monthly average, expressed in kilograms (pounds) of pollutant per day which is the total of each pollutant discharged in a calendar month divided by the number of days the production facility operated that month.

2. Daily maximum, expressed in kilograms (pounds) per day.

Maximum daily limitations have not been statistically established for all industrial categories. It is our intent that the discharge limitations developed from the guidance and other considerations be a monthly operating average and a daily maximum. Variations from this operating average will be monitored and used as a basis for judgment of the performance of the discharger and to establish statistical variability. When statistically reliable data is available, a maximum variation will be established on that basis. Until such is the case, a general limitation for individual composite data shall be established that is no more than 3 times the average limitation (200% over) where water quality considerations do not prevail. Discharges may be limited singly or as a group or a combination of single discharges and groups or totally for the plant depending on the engineering judgment of the reviewer. It may be necessary to know the source of each discharge before making such a judgment. In any case, the total allowance of pollutant limitations should not exceed that calculated for the total plant production capability. Monitoring programs and compliance schedules should be consistent with approach chosen.

Production Figures to be Used in Permit Writing

A manufacturer should not be limited to less than full utilization of actual installed production capability. However, do not allow the purpose of effluent limitations to be circumvented by overstatements of production capability. The manufacturer is responsible for meeting the permit requirements without regard to seasonal variations in treatment efficiency, production levels, or product mix.

Therefore, the "production" figure can be either product or raw material as appropriate; shall be based on plant production capability whether by engineering evaluation or production history; and shall be based on the normal equipment operating schedule.

Where production units are separated, but utilize a common treatment facility, production will be evaluated for the production complex as a whole. One permit would be written for the production complex, covering all discharges to receiving water individually or combined as appropriate.

Where "production" is based on product, the total produced (including that shipped out of plant and/or placed in inventory) will be used. Similarly, where raw material (not including process chemicals) usage is the basis, the total processed will be used. In either case, assume a reasonable product mix which most fully utilizes installed equipment.

For complex facilities, the capacity will be limited by the unit process which controls production, e.g., if an intermediate process can only supply 75 units to a downstream operation with a capability of 100 units, then the overall capability is 75 units unless purchased intermediate material is introduced. The determination, further, should be based on a normal operating schedule, e.g., shifts per week. There may be cases where increased production requirements are anticipated, and will be met by a heavier operating schedule (running the equipment more shifts per week). The heavier operating schedule may be used in defining plant capacity, but should be supported by market projections, production schedules, etc., that demonstrate the intent.

The production figure arrived at in this manner should not be an unreasonable deviation from historical actual production.

In any event, the manufacturer can apply for re-issuance of his permit based on increased production. As a rule-of-thumb, this should only be necessary when the contemplated production increase would cause overloading of treatment facilities, resulting in violation of the effluent limitations in the permit.

Level A and Level B

Minimum levels of treatment (B Level) were originally proposed in recognition of the economic hardship implicit in redirecting a pollution abatement program already under construction. However, setting specific minimum limitations for all industry raised the possibility of an implied benefit to dischargers only recently providing treatment. In addition, subsequent amplification of "best practicable control technology currently available" requires consideration of economic cost benefit relationships, as well as engineering aspects, non-water quality oriented environmental impact and others.

The primary mechanism of relief will be reflected in compliance schedules terminating with acheivement of Level A guidance by July 1, 1977. The most important consideration in using Level A and Level B is to remind the discharger that Level A values are to be met as a minimum requirement by July 1, 1977, by all dischargers.

Permit Duration

Permits may be issued for periods up to five years. If a discharger is expected to achieve A levels by July 1, 1977, and he commits to a program to accomplish this, he will expect a permit of extended duration, i.e., five years. Short term permits, e.g., less than 3-5 years, should be issued only in those situations where there is a significant water quality problem that may not be resolved or where the technology for pollution abatement is not, in your opinion, sufficient, or where the discharger is not sure of the success of his planned program. In these instances the permit should be written to terminate 9 months after the conclusion of the compliance plan.

Settleable Solids

The presence of settleable solids in treated effluent can show biological system misfunction and clarifier misoperation, assuming it is well designed. The absence of settleable solids can therefore indicate continuing operational stability. Analysis for settleable solids may be a useful monitoring tool to supplement and, to a certain extent, reduce the frequency of BOD_5 and suspended solids analyses, thus providing greater operational control.

Staged Discharge

There may be instances where variability in receiving water flow (either regulated or natural causes) precludes discharge of even very highly treated wastewater due to stream quality considerations during low flow periods. In such instances, treated wastewater may be stored for discharge when receiving water considerations allow it. The discharge permit may therefore contain supplemental conditions permitting discharge in regulated amounts. In any case the total weight of individual pollutants so scheduled shall not exceed an appropriate limitation based on production capability.

Batch, Seasonal and Intermittent Operations

Batch, seasonal, and intermittent operations will be limited in the same terms as are continuous operations, i.e., a monthly operating average and a daily maximum, each expressed in pounds per day of individual pollutants. It may also, however, be necessary to set a limit on the rate of discharge in terms of pounds per hour in order to prevent violation of receiving water quality standards due to slug discharge.

The rationale is based upon the essential logic in the discussion of 'production capability' plus a general condition in each permit requiring that the permittee operate the treatment facilities efficiently at all times. No attempt should be made to specify the days upon which a discharge is authorized.

Monitoring and Self Reporting

Separate guidance has been written for monitoring and self reporting. Generally the approach is that the permittee notify the regulatory agency in the event of violation of a daily maximum limitation (in which case, if immediate telephone notification is required, a 24-hour telephone number should be supplied), and that the permittee shall monitor and report routinely at such a frequency as to assure management and the regulatory agency that abatement programs are being implemented and the permit terms and conditions observed. Any discharge characteristics that are limited should be monitored, not necessarily all at the same frequency. Avoid limiting the same characteristic by more than one limitation; for instance, oxygen demand by BOD_5, COD and TOD.

Compliance Schedules

Proposed or tentative compliance schedules should be expressed in months elapsed from the effective date of the permit until the permit is issued at which time specific dates should be typed into the schedules. Interim limitations for 'immediate' compliance (e.g., one month from effective date) should be imposed as necessary and desirable in order to either abate an "imminent hazard to public health or safety" or because it is feasible to abate the discharge immediately. Compliance with other limitations may require installation of waste treatment facilities, which would require additional implementation and compliance schedules.

It should be noted that a pollution abatement program for a complex industrial facility may involve installation of more than one treatment facility. Our interest is in the end result, not on the design or program planning, excepting insofar as total compliance is achieved in a timely manner not to exceed July 1, 1977. Therefore, in a staged program, interim limitations may be imposed based upon completion of facets of an overall abatement program.

Treatment models described in the guidance are not intended to specify procedures or processes, but to illustrate the means by which the limitations may be met. Alternatives which will achieve the same end are acceptable.

Metric Units

All permits should be written in metric units (kilograms, meters, kiloliters) with equivalent English units (pounds, feet, gallons) in parentheses alongside.

APPLICABILITY

These instructions apply to Standard Industrial Classification Codes 11 and 12.

SUBCATEGORIES CONSIDERED

Operations in the coal mining industry are considered under the following subcategories: coal preparation plants, underground coal mining, and surface mining (strip mining).

OPERATIONS EXCLUDED

This guidance covers only the listed operations. Hardrock mining, specifically, is excluded.

APPLICATION OF LIMITATIONS

Concentrations schedule (A) should be applied for mine drainage and preparation plant discharges, with the exception of the alkalinity criteria, which should be changed to acidity with an upper limitation of 10 mg/l in both cases. This guidance should not be used as a basis for surface mining permits and priority should be placed on significant dischargers.

Wastes from coal mining operations often are unrelated, or only indirectly related, to production quantities. Therefore, effluent limitations are expressed in terms of concentration rather than units of production. Due to the wide variation of geological and hydrological factors in the coal industry, a pound per day limitation is impractical.

EFFLUENT LIMITATIONS

Underground Mine Drainage

1. There shall be no dilution of the effluent stream.

Surface Mining

1. The velocity of discharge shall be such that scouring of stream bed shall not occur.

2a. All treatment facilities shall be of sufficient size to handle the run-off resulting from a once-in-ten-years' storm. (Source-Kentucky revised statutes relating to strip mining and reclamation, 1966, Chapter 350, Regulation 11.)

EFFLUENT LIMITATIONS (Continued)

b. The effluent shall not contain suspended matter in excess of 30 mg/l, (A level) or 100 mg/l, (B level) with the exception of during and four hours after a major precipitation event.

The operator is not at any time to discharge an effluent containing suspended matter in excess of 1,000 mg/l from any area of land affected. A major precipitation event is the number in inches of water greater than the duration of the storm in minutes divided by 100 plus 0.2. (Source - U.S.D.A. miscellaneous publication #204, "Rainfall Intensity and Frequency Data, 1935.) (See Graph)

Since the operator must show the major precipitation event has occurred, it will require an installation at the operating site of a recording rain gauge. In addition, precipitation must be included in the monitoring program.

Area of land affected is the area of land from which overburden is to be or has been deposited, which shall include all land affected by the construction of new roads or the improvement or use of existing roads, other than public roads, to gain access and to haul coal.

c. Sudden release of large volumes of water from the treatment facility, as during a storm, must be prohibited to prevent scouring of the treatment facility. Therefore, there should be established a level at which the flow will be diverted from the treatment facility. This level must be set for each individual operation taking into consideration the following (i) average precipitation of area; (ii) receiving stream water quality standards; and (iii) the volume of water discharged during a once-in-ten-years' storm.

The applicability of any of the parameters listed must be at the discretion of the Regional Administrator.

ABATEMENT MODELS

The effluent limitations for the coal mining industry are based on utilization of the geochemical approach which encompasses oxidation potentials, reaction rates, and solubility constants, as well as pH control.

A. Preparation Plant Wastes

Semi-colloidal particles of coal, shale, and clay in suspension form one of the principal pollutants--suspended solids. Reduction in the amount of suspended solids reaching the stream can be achieved by installation of settling and impounding facilities. Other methods of control include froth flotation, flocculation, filtration, and mechanically operated sedimentation and clarification basins. Organic coagulants such as polyacrylamide, used alone or in combination with inorganic coagulants, may demonstrate good settling qualities.

In addition to the problem of suspended solids, the effluent from coal washing-may contain iron and sulfur compounds in suspension.

In high enough concentration, these would cause considerable loading on the stream and will require chemical treatment before discharge. The effluent limitations for preparation plant wastes reflect the eventual goal of complete recycling.

B. Underground Mine Drainage

The term "underground mine drainage" as used herein applies not only to discharges which have a low pH value but also to discharges with a neutral value but which are high in metallic salts which can be a problem in an alkaline environment.

Drainage from coal mines may be acid and may contain sulfuric acid, ferrous and ferric iron, aluminum, and manganese in significant concentrations. Carbon dioxide, and calcium, magnesium, and sodium salts, all of which contribute to a very high degree of hardness may also be present. Preventive measures might include reduction of the amount of infiltration into the mine, controlled dewatering to reduce contact with acid-forming materials, removal of acid forming materials, sealing or flooding of inactive mines, and replacement of waste rock. Treatment methods which might be used to meet the effluent requirements include neutralization, and removal of iron and manganese.

C. Surface Mining

To meet the effluent limitations for surface mining, operators will have to employ one or all of the following methods:

1. Keep as much water as possible out of the operating site;
2. Provide proper drainage and removal to a treatment facility;
3. Separate contaminated and non-contaminated water; and
4. Insure that all water receives proper pH control as well as removal of suspended solids and metallic materials.

ABATEMENT MODELS (continued)

At present, a number of operations are employing lagooning systems. Evaporation results in a reduction in the suspended solids as well as the ferric hydroxide and the ferric sulfate. Precipitation eventually results through the oxidation process.

One source of acid mine water is the reuse pile or "gob pile" which contains sulfurous refuse from the preparation and cleaning process. Control of the gob piles could eliminate a source of acid drainage. The simplest system for control is to cover these piles with a non-acid producing material such as two feet of dirt. At a later time, to insure stability, some form of vegetation should be planted. Sealing or benching of the cut area so that there are no opportunities for oxidation of pyritic material will eliminate a major part of the problem.

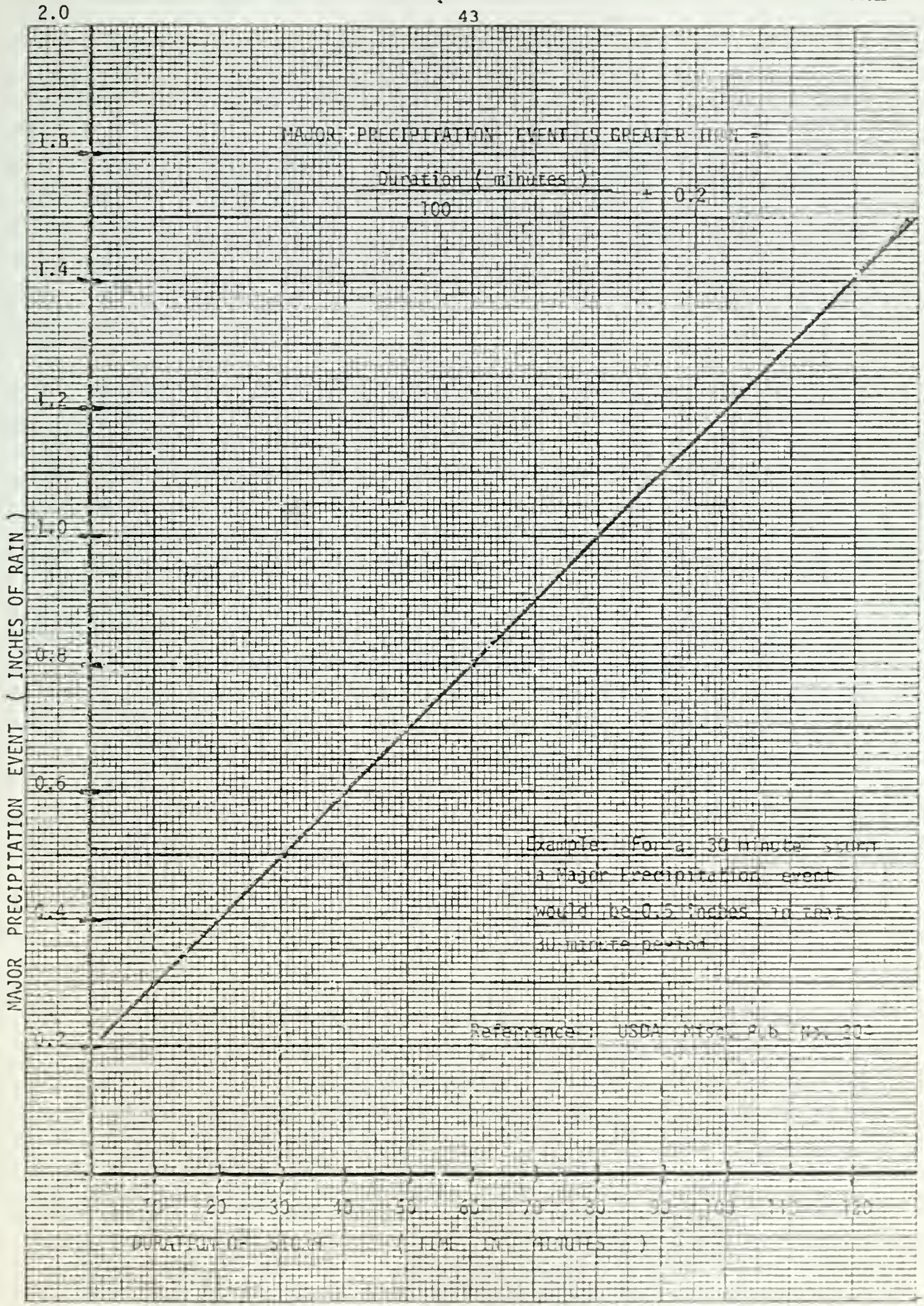
Neutralization

Neutralization to pH of 6.0 to 9.0 can be accomplished by the use of lime, limestone, oxidation, or varied combinations of the three depending on the characteristics of the waste.

The use of a two-step neutralization process, that is, the use of limestone to bring the pH to 5, with the addition of lime to complete the neutralization, could result in a considerable savings both in the cost of chemicals and in sludge handling.

EFFLUENT LIMITATIONS

	Preparation Plants		Underground Mine Drainage		Surface Mining	
	A	B	A	B	A	B
Suspended Solids	30 mg/l	40 mg/l	30.0 mg/l	40 mg/l	30.0 mg/l	100 mg/l
pH	6.0-9.0	6.0-9.0	6.0-9.0	6-0-9.0	6.0-9.0	6.0-9.0
Total Iron	4.0 mg/l	7.0 mg/l	4.0 mg/l	7.0 mg/l	4.0 mg/l	7.0 mg/l
Alkalinity	Greater than acidity *1		greater than acidity *2		greater than acidity *3	



Example: For a 30 minute storm a Major Precipitation event would be 0.5 inches in that 30 minute period

Referrance : USDA Misc. Pub. No. 20

APPENDIX #10

NOISE SURVEY OF BIG SKY MINE, ROSEBUD COUNTY, MONTANA

By

Peabody Coal Company

NOISE SURVEY OF
BIG SKY MINE, ROSEBUD COUNTY, MONTANA

RESULTS AND EVALUATION

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(*) See attached resumes

NOISE SURVEY OF
BIG SKY MINE, ROSEBUD COUNTY, MONTANA

RESULTS AND EVALUATION

I. INTRODUCTION

The first set of noise measurements to determine the environmental impact of Peabody's Big Sky Mine were made during the morning and afternoon of July 25, 1973. During the entire period of noise measurements the mine was operating at full capacity and rail cars were being loaded with coal. Blasting noise was not measured at this time because (1) the mine had a considerable amount of uncovered coal, and had no immediate need to do any blasting, and (2) magnetic tape recording equipment to be used in measurement of the blast transient was not yet available from the manufacturer. (This equipment is presently on order with General Radio, but delivery is expected to be December, 1973 or later.) The final set of noise measurements, which will be directed to blasting noise, will be made soon after the tape recording equipment becomes available. A report on this activity will then be written and appended to this present report.

It is important to recognize the fact that there are no ground rules laid down by any governmental authority for the conduct of a noise survey. It is equally important to realize that these measurements represent only one point in time. Obviously, the location of the pit will change as time goes on, and the location will bear directly on its impact. For awhile the mining pit will be closer to Highway 315 than it presently is, but for most of the life of the mine the pit will be much further from the highway.

II. PRIMARY EMPHASIS OF THE SURVEY

As stated previously, there were no guidelines for this study. Consequently, it was established that the primary emphasis in this survey would be to measure mining noise at the mine property boundaries which lie between the mining operations and populated areas. To our knowledge only three populated areas exist near the mine. One is the coal-mining town of Colstrip, which lies about 5 miles NNW of the pit, another is a small trailer court located about 2 miles NE of the present pit, and the third area is along a NE-SW road 3-1/2 miles SE of the present pit. About 4 houses are located on this road.

III. GENERAL OBSERVATIONS

A. LOCATION OF THE MINE

Possibly the most important single fact about the mine is that it is essentially isolated from populated areas by buttes which are about 300 feet high. Mining will take place in the valleys between the buttes, so the mining operation will be acoustically baffled by the buttes and the vegetation lying between the mine and populated areas. As will be shown in the discussion of the measurements, the effect of the buttes is to completely deaden the normal operating sounds of the mine. We do not yet know whether explosive sounds will be completely deadened, but we are certain that such sounds will be drastically attenuated.

There is one exception to this. The trailer part is not isolated from the mine by ridges. In its present location it is far enough away that normal mining sounds are quite reduced, even though they are audible. However, when mining progresses into section 13 of mining area "A", the mine will be

very close to the trailer court. It may become necessary then to move the trailer court to another location a few miles away.

B. EFFECTS OF NOISE ON WILDLIFE

No attempts have been made to determine the effects of mining noise on wildlife, but the following observations have been made. The Mine Superintendent, Mr. Alfred Caskey, reports that big game and cattle seem unaffected by mining operations. Deer, pronghorn antelope, and cattle frequently feed very close to the mining operations and the haulage roads, sometimes less than a quarter mile from the center of operations. They seem to have completely adapted to the presence of large machinery and its associated noise.

C. OTHER NOISES IN THE ENVIRONMENT

In the proximity of the mine there are two other sources of non-natural noise. One is the traffic on Montana Highway 315, which skirts the eastern and northeastern boundaries of the mine. This traffic is fairly light. The other is the noise from the Western Energy Mine, which lies 3-4 miles NW of the Big Sky Mine office. These noises dominate in measurement locations (1), (4), (7), and (8), but the noise levels were by no means objectionable.

There are very few sources of natural noise in this area. The area is similar in many respects to the high sagebrush desert of central Utah, except there is probably more grass here in Montana. The buttes are partially wooded by scattered stands of pine and juniper. The greater part of the land is void of trees, and is vegetated primarily by thin grasses, sagebrush, yucca, and prickly pear castus. In areas where no highway or mining noise can be heard, the only sounds usually heard are those of insects, birds, USAF jets, and the wind blowing through the trees or the grass.

IV. MEASUREMENTS AND RESULTS OF THE NOISE SURVEY

A. WEATHER CONDITIONS

Weather conditions were excellent for the survey. The temperature varied between 82°F. and 90°F, and the day was sunny, clear, and reasonably calm. Under such conditions one would expect uniform propagation, with no channelling or shadow-zoning. Measurements were made at eight locations about the property boundary, four in the morning and four in the afternoon. The wind was very light in the morning, possibly varying between 1 and 4 mph. The wind increased somewhat over the lunch hour, and was gusting between 8 and 12 mph.

B. EQUIPMENT

The instrument used for the survey was a new General Radio Model 1933 Precision Sound-Level Meter and Analyzer, in conjunction with a 1 inch Electret Condenser Microphone. This instrument was calibrated immediately prior to the survey with a General Radio Model 1562 Sound Level Calibrator. A wind screen was used during part of the measurements.

Determinations of location were made by using a contour map and a pocket compass. Location was roughly determined by recognition and direction, and was then more accurately defined by triangulating on prominent landmarks.

C. THE MEASUREMENT RESULTS

Measurements were made in eight different locations, and these locations are shown by number on Figure 1. Locations 1 through 4 were chosen to determine the noise impact of the mine on the community of Colstrip. Locations 5 and 6 were to determine the noise impact on the trailer court, and locations 7 and 8 were primarily for general background information.

At the time of the survey the contour map of Figure 1 was not available, and we were not aware of any houses south of location (8). However, based on measurements made in locations explained, and knowing that there is more than 3 miles of rough terrain and buttes between the mine and these houses to the south, we would venture the opinion that mining noises would not be audible at these houses. This opinion will be verified during the final part of the survey.

The measurements made at each location have been graphically displayed in Figures 2 through 9. Following are commentaries on each location's result:

LOCATION 1 This set of measurements was made on top of a small hill just beyond the crest of the main ridge running along the northern property boundary. Except for birds chirping and insects buzzing about, this location was practically silent. Haulage trucks could be heard in the distance toward the Western Energy Mine, but the noise levels were clearly not objectionable. In fact, as Figure 2 shows, only those sounds lying above 63 Hz were loud enough to be perceived by human ears, and at levels quieter than most residential bedrooms.

LOCATION 2 Located atop the ridge overlooking the mine, this location offered a totally unobstructed view of the mine. The geometry of the situation was such that very little excess attenuation would be expected, because there were no intervening trees or hills. During this and the next two sets of measurements a drill rig was operating in the SW corner of section 14 (see Figure 1). The drill rig was not audible.

The sounds of the mine were audible from this location, but all except two were quite muffled. The two sounds that were clearly audible were the haulage trucks as they climbed the inclined roads out of the pits, and the backup alarms on the mobile vehicles. The backup alarms, which are required by the Mine Health and Safety Act, emit a penetrating and persistent noise which is obviously the most irritating of all the mine noises.

LOCATION 3 This location was very similar to location 2, except there were a few trees between us and the mine, and there was a long butte extending along our line of sight toward the mine. Except for the 63 Hz readings, the noise spectra were nearly identical. There is no explanation for the rise in 63 Hz noise power between these two locations, but it is possibly the result of another piece of equipment being turned on.

LOCATION 4 This point was specially chosen to lie directly between the mine and Colstrip, Montana. It was located about 1/4 mile north of the ridge which runs the northern property boundary of the mine. The only perceptible sounds, aside from the deer flies and wind in the grass, was the faint sound of haulage trucks in the

direction of the Western Energy Mine. Low frequency noise was higher than it was in Location 1, which was a similar location.

The quietness of location 4 leads one to the conclusion that the noises of the mine could not be heard at Colstrip except under very unusual channelling or convergence conditions.

LOCATION 5 This location was only 1/2 mile NE of the tipple, and 1-1/2 miles NE of the pit. There were no intervening hills or trees. As expected, noise levels were much higher in this location than any previously made. Low frequency noise had a large spread of values, probably caused by the wind gusts that had arisen by this time. Perhaps more significantly, the curve (shown in Figure 6) of level versus frequency has a prominent "knee" in the 1000-2000 Hz frequency band. The fact that this knee does not exist at other locations may indicate that these frequencies are attenuated rapidly with distance.

LOCATION 6 Carefully chosen to assess the impact of mine noise on the trailer court, this measuring location was just outside the fence surrounding the trailer court, and was directly between the trailer court and the mine. It is difficult to show in graphical form, but the measurement values also reflect noise from a large group of birds that were in the trees around the trailer court. Light gusts of wind also gave a measuring problem here, because the general noise level was so low that bird chirps and wind gusts drove the meter needle off-scale.

The 250 Hz and 500 Hz noise levels were higher near the trailer court than they were at location 5, which was about 1/2 mile closer to the mine. Since most electric motor noise peaks up in the 250-500 Hz range, this rise in noise levels may be attributable to electric motors used in the trailer court.

LOCATION 7 Measurements at this site were made just north of the mine road intersection with Highway 315. For the portion of the spectrum lying between 63 and 2000 Hz, the levels here were much lower than they were in locations 5 and 6. This is to be expected, because although the distance to the pit was about the same, this site has trees and hills between it and the pit.

Untypically high maximum levels were noted in the 31.5 Hz and 63 Hz bands, and this was directly attributable to the wind. Even though a wind shield was being used, and no measurements were made when cars were passing, the wind had risen enough by this time that it was extremely difficult to measure in lower frequency bands.

LOCATION 8 This area was so quiet that octave-band measurements were impossible to make, due to the noise of light wind gusts and insects. It was possible, however, to obtain a dBA reading at this location, because the dBA weighting networks in the meter tend to deemphasize the lower end of the spectrum, where wind noise gives the most problem.

V. EVALUATION OF THE RESULTS

It is difficult to attach any particular significance to the curves shown in Figures 2 thru 9 unless one has a point of reference. For the purpose of relating these curves to more familiar noise levels, we have inserted in the back cover of this report a transparent overlay of Preferred Noise Criteria (PNC) curves.(1) The PNC curves relate suggested noise ranges for various indoor functional areas, as explained in Table I.(2)

As an example of how to use the overlay, place it over Figure 2 and make sure the graph coordinate values overlap. In most cases the measured noise levels in Figure 2 are less than PNC-20, and in no case do they exceed PNC-23 (not shown). What does this mean? Referring to Table I we see that this level is much quieter than recommended levels for bedrooms, hospitals, and other areas used for sleeping, resting, and relaxing.

Another thing shown in Figure 10 is a curve representing the human threshold of hearing, which has also been included on Figures 2 through 9 for reference. In most locations it is noted that 31.5 Hz and 63 Hz noise is not loud enough to be heard.

The highest overall levels measured were at location 5, at which the levels ranged between PNC-20 and PNC-40. Again referring to Table I, these levels are within the range of levels recommended for bedrooms, hospitals, and other areas used for sleeping, resting and relaxing.

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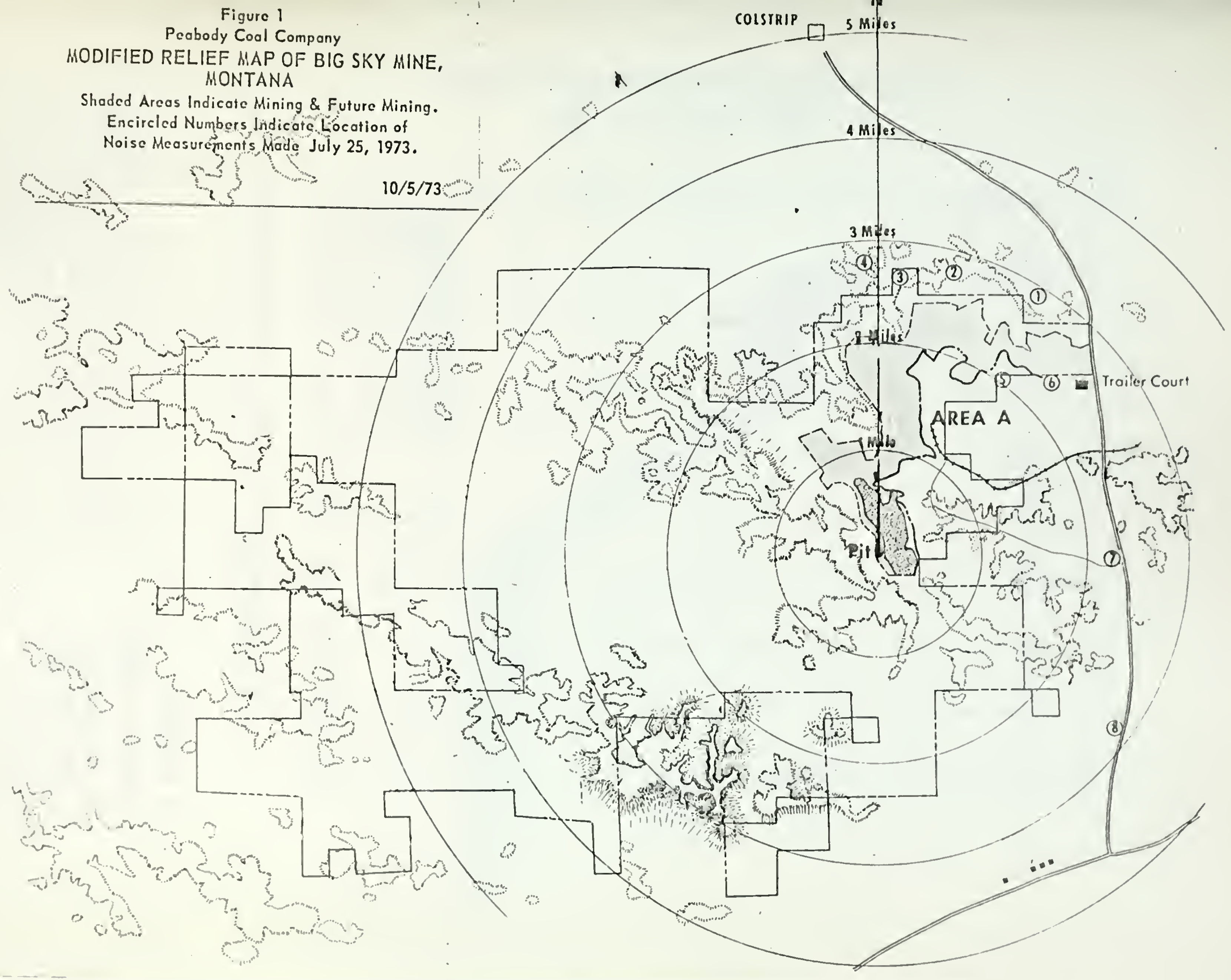
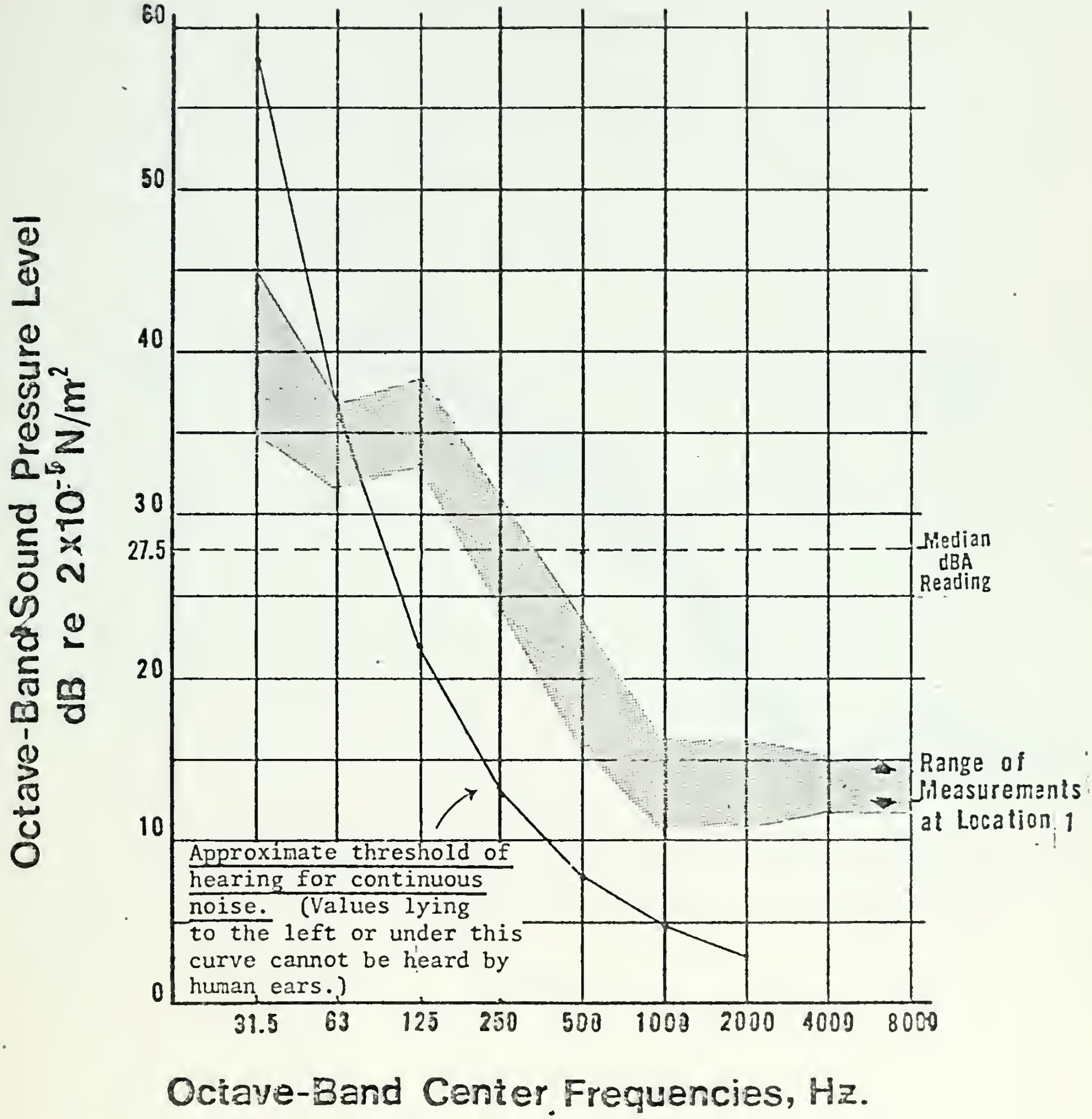
(1) NOISE AND VIBRATION CONTROL, Leo L. Beranek, page 567, fig. 18.3, McGraw-Hill, 1971.

(2) Ibid, page 585, table 18.7.

Figure 1
Peabody Coal Company
MODIFIED RELIEF MAP OF BIG SKY MINE, MONTANA
Shaded Areas Indicate Mining & Future Mining.
Encircled Numbers Indicate Location of
Noise Measurements Made July 25, 1973.

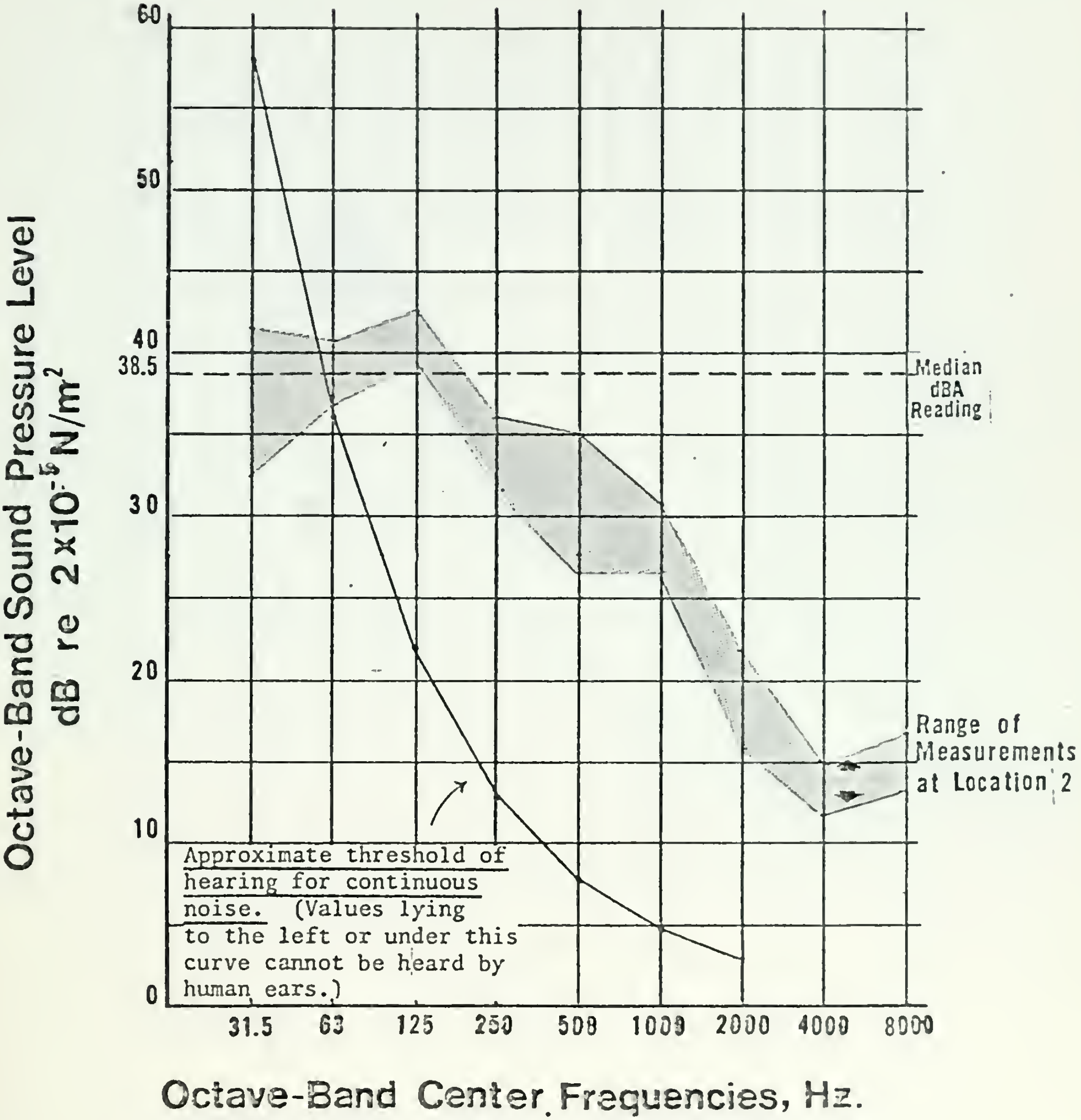
10/5/73





Comments: Measured at a point over the crest of the ridge on the north property. The wind was virtually calm, and the only noises discernible were the distant haulage trucks of the Western Energy Mine and chirping of birds nearby.

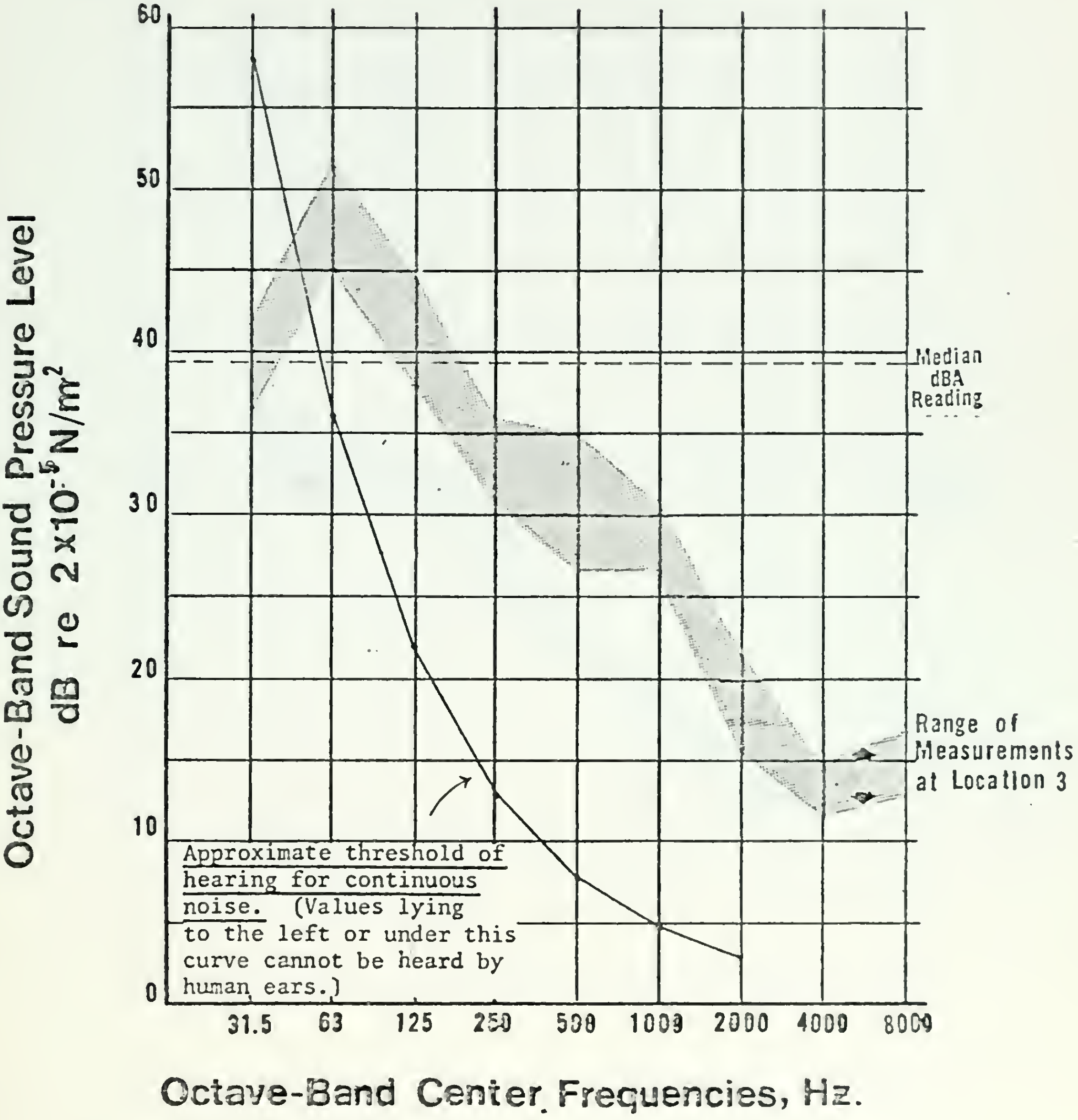
Figure 2
Noise Levels
Measured At
Big Sky Mine
July 25, 1973, a.m.
Location 1



Approximate threshold of hearing for continuous noise. (Values lying to the left or under this curve cannot be heard by human ears.)

Comments: These measurements were made on top of the ridge about a quarter mile beyond the north property boundary. The mine was visible from this location, and certain mining noises such as haulage trucks and backup alarms were clearly discernible.

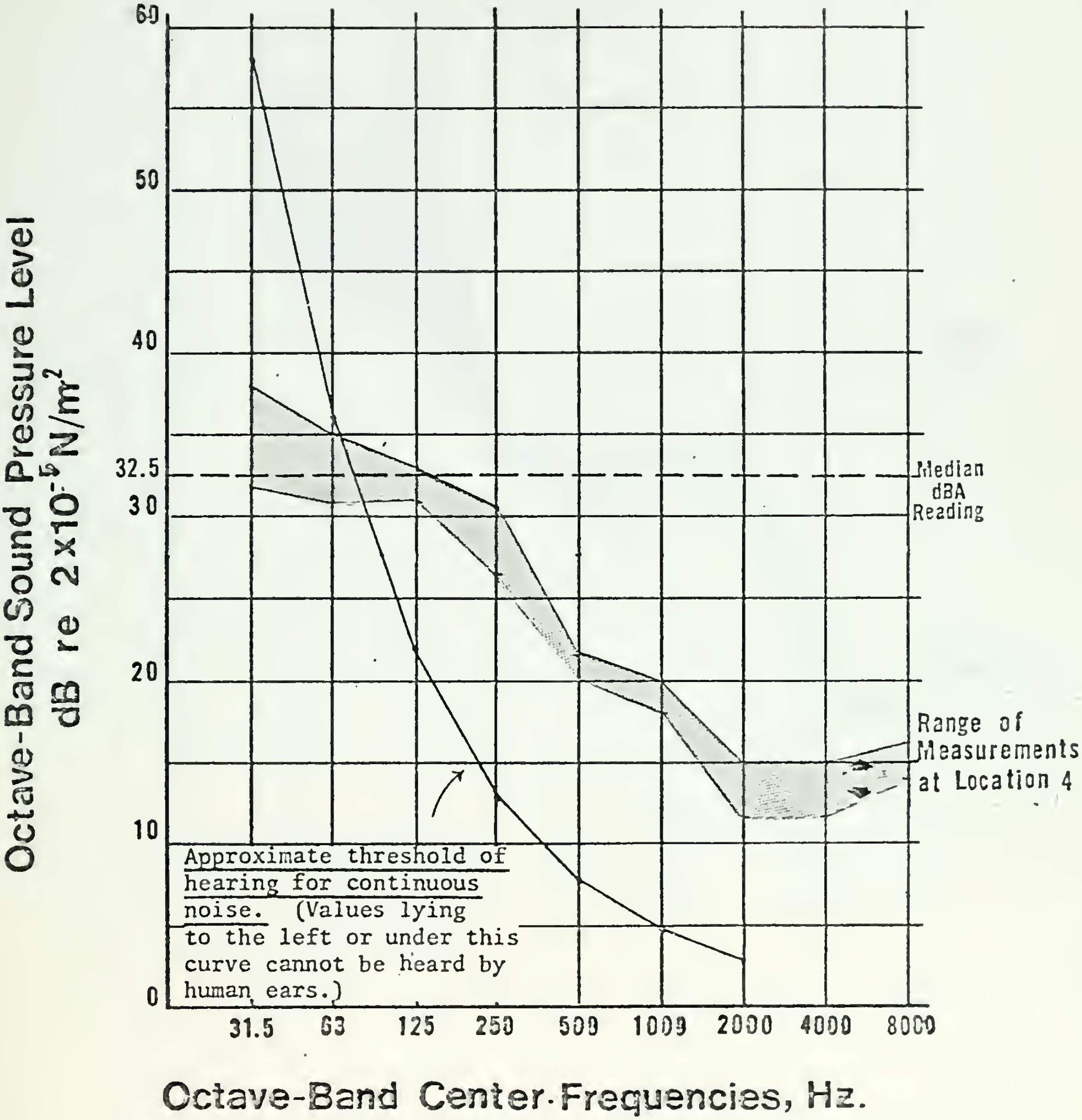
Figure 3
Noise Levels
Measured At
Big Sky Mine
July 25, 1973, a.m.
Location 2



Approximate threshold of hearing for continuous noise. (Values lying to the left or under this curve cannot be heard by human ears.)

Figure 4
Noise Levels
Measured At
Big Sky Mine
July 25, 1973, a.m.
Location 3

Comments: Measured at a point near the northern property boundary, from a ridge overlooking the mine. The mine was visible from this location, and certain mining noises such as haulage trucks and backup alarms were clearly discernible.



Comments: Measured at a point near the northern property boundary lying directly between Colstrip, Montana and the mine. Only discernible sounds at this location were from the vicinity of the Western Energy Mine, and sounded like haulage trucks.

Figure 5
Noise Levels
Measured At
Big Sky Mine
July 25,1973, a.m.
Location 4

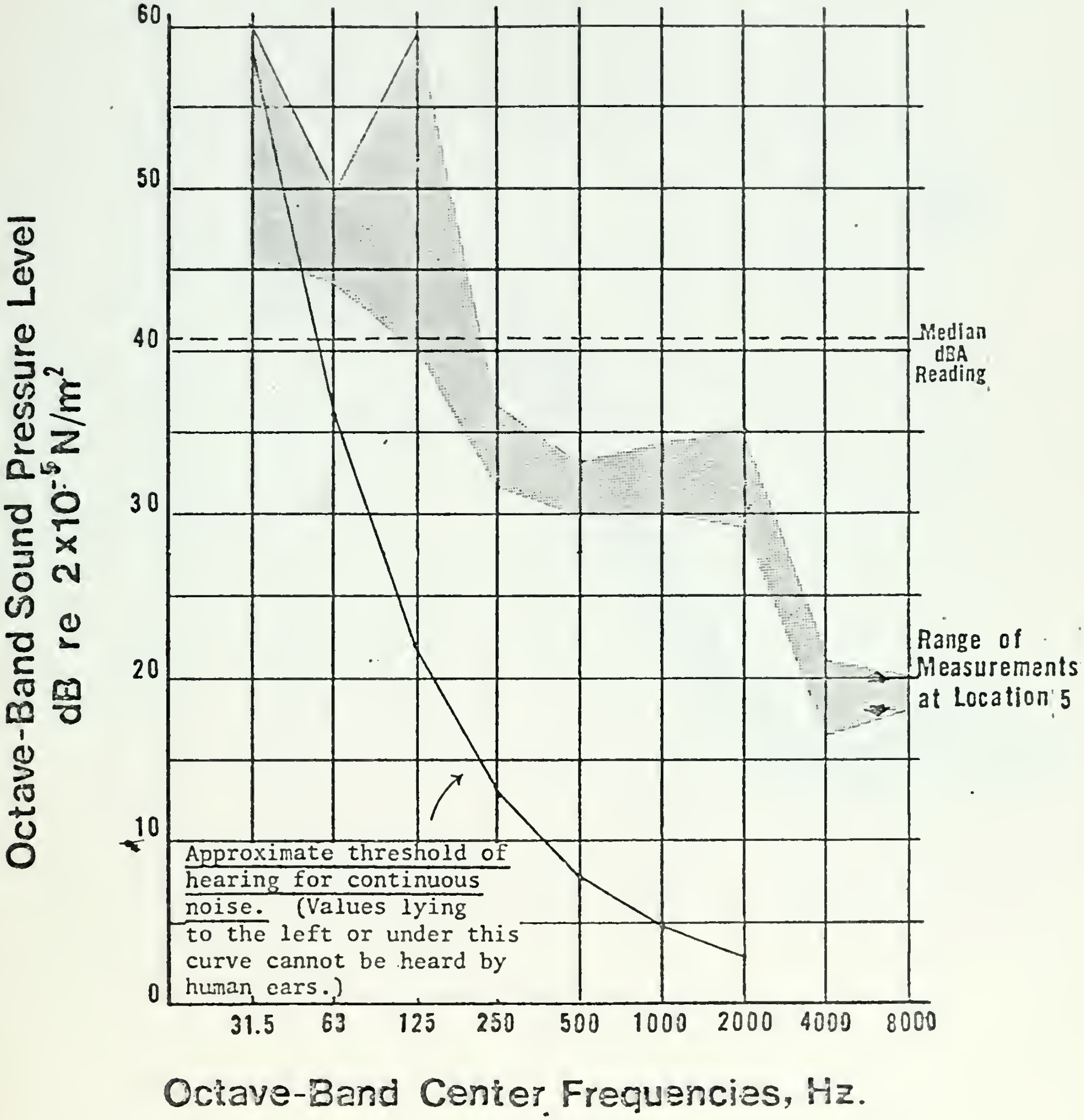


Figure 6
Noise Levels
Measured At
Big Sky Mine
July 25, 1973, a.m.
Location 5

Comments: These measurements were made on a flat area about 1 mile from the pit. Mine noises were clearly audible, primarily dominated by noise from haulage trucks and backup alarms.

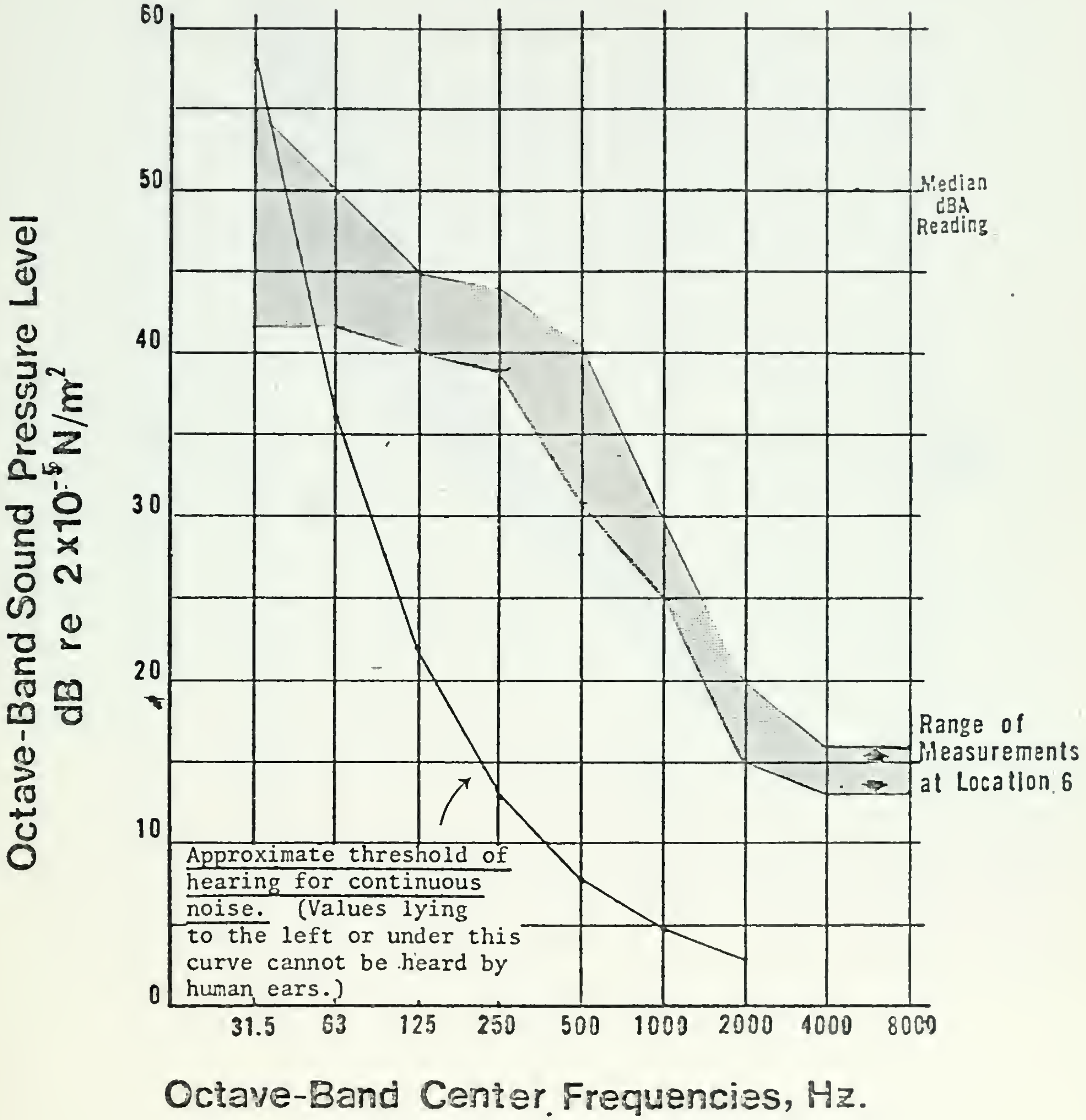


Figure 7
Noise Levels
Measured At
Big Sky Mine
July 25,1973,a.m.
Location 6

Comments: Measurements were made just outside the fence on the west side of the trailer court, between the trailer court and the mine. Mine-originated noise levels in the trailer court should be much lower than the above low values, because the heavily vegetated trees in the court will attenuate sound effectively.

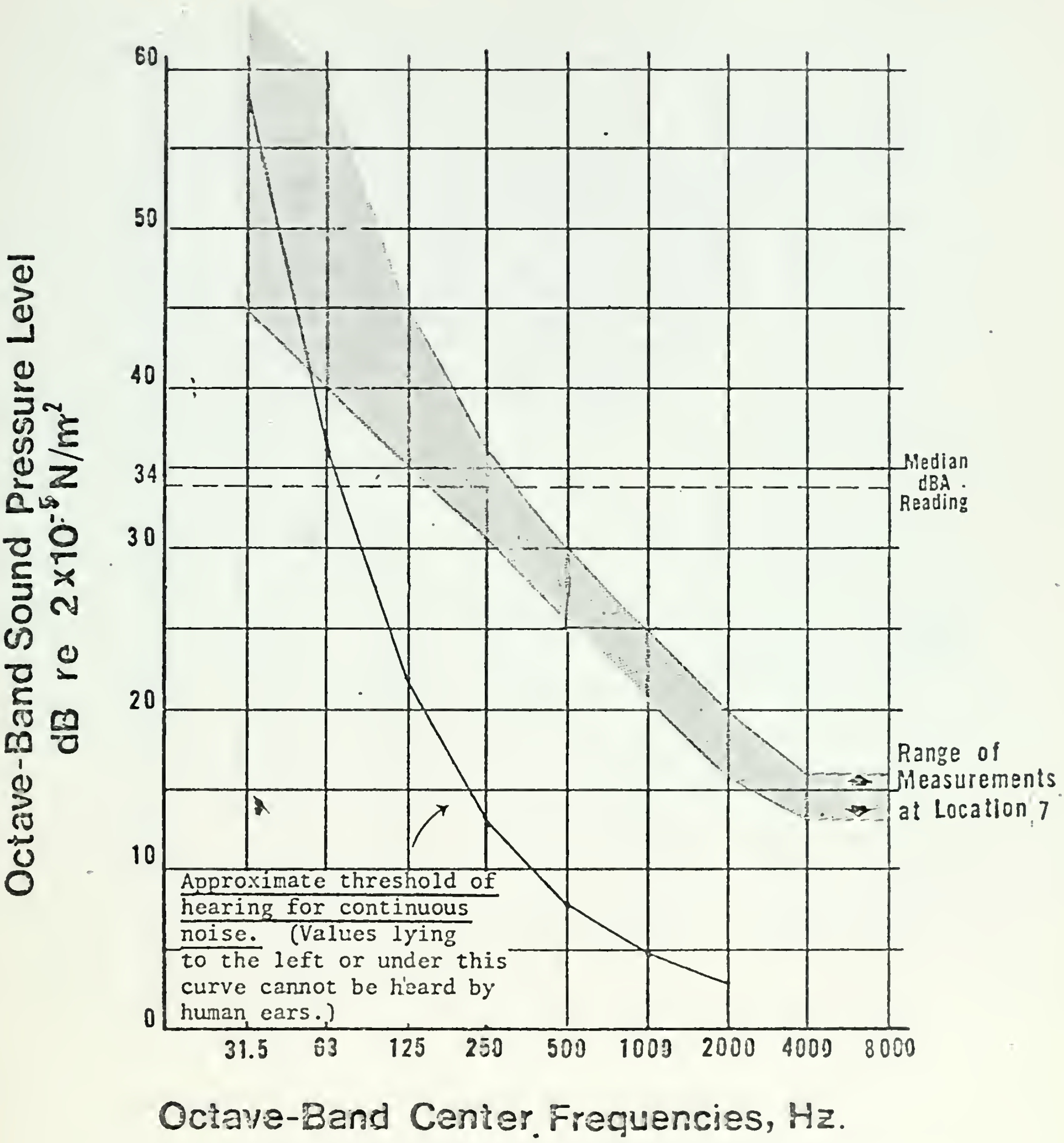
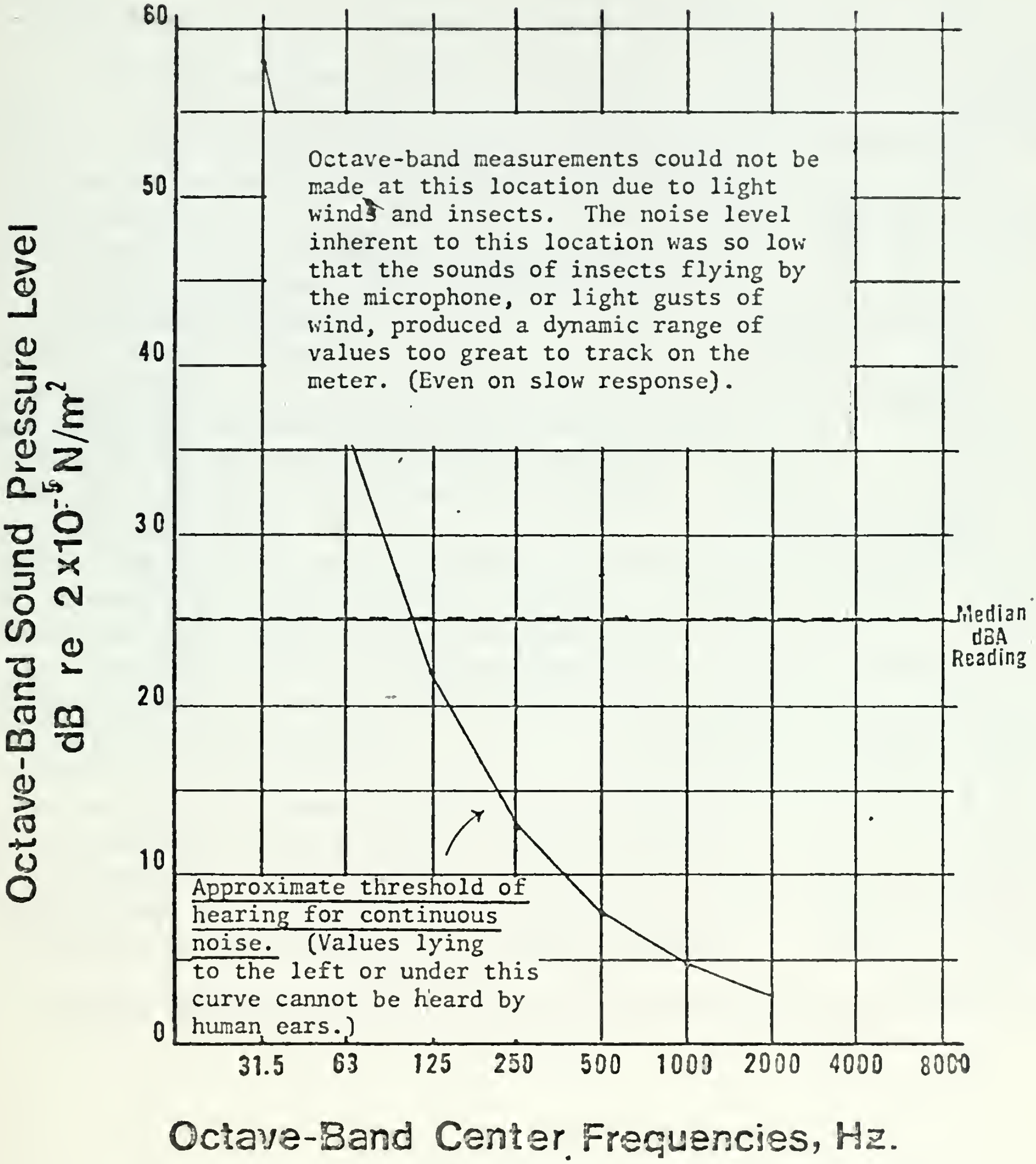


Figure 8
Noise Levels
Measured At
Big Sky Mine
July 25,1973,p.m.
Location 7

Comments: These measurements were made near the intersection of the mine road and Montana Highway 315. The only audible noises were occasional passing traffic, insects, and wind, which was gusting between 8 and 12 mph.



Octave-band measurements could not be made at this location due to light winds and insects. The noise level inherent to this location was so low that the sounds of insects flying by the microphone, or light gusts of wind, produced a dynamic range of values too great to track on the meter. (Even on slow response).

Approximate threshold of hearing for continuous noise. (Values lying to the left or under this curve cannot be heard by human ears.)

Figure 9
Noise Levels
Measured At
Big Sky Mine
July 25,1973,a.m.
Location 8

Comments: These measurements were made about 1.8 miles south of the entrance to the mine road, and about 75 yards west of Montana Highway 315.

Type of space (and acoustical requirements)	PNC curve	Approximate L_A, dBA
Concert halls, opera houses, and recital halls (for listening to faint musical sounds)	10 to 20	21 to 30
Broadcast and recording studios (distant microphone pickup used)	10 to 20	21 to 30
Large auditoriums, large drama theaters, and large churches (for very good listening conditions)	Not to exceed 20	30
Broadcast, television, and recording studios (close microphone pickup used only)	Not to exceed 25	34
Small auditoriums, small theaters, small churches, music rehearsal rooms, large meeting and conference rooms (for very good listening), or executive offices and conference rooms for 50 people (no amplification)	Not to exceed 35	42
Bedrooms, sleeping quarters, hospitals, residences, apartments, hotels, motels, etc. (for sleeping, resting, relaxing)	25 to 40	34 to 47
Private or semiprivate offices, small conference rooms, classrooms, libraries, etc. (for good listening conditions)	30 to 40	38 to 47
Living rooms and drawing rooms in dwellings (for conversing or listening to radio and television)	30 to 40	38 to 47
Large offices, reception areas, retail shops and stores, cafeterias, restaurants, etc. (for moderately good listening conditions)	35 to 45	42 to 52
Lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas (for fair listening conditions)	40 to 50	47 to 56
Light maintenance shops, office and computer equipment rooms, kitchens and laundries (for moderately fair listening conditions)	45 to 55	52 to 64

Ref. NOISE AND VIBRATION CONTROL, Leo L. Beranek, page 585; Table 18.7 McGraw-Hill, 1971.

TABLE I. RECOMMENDED CATEGORY CLASSIFICATION AND SUGGESTED NOISE CRITERIA RANGE FOR STEADY BACKGROUND NOISE AS HEARD IN VARIOUS INDOOR FUNCTIONAL ACTIVITY AREAS.

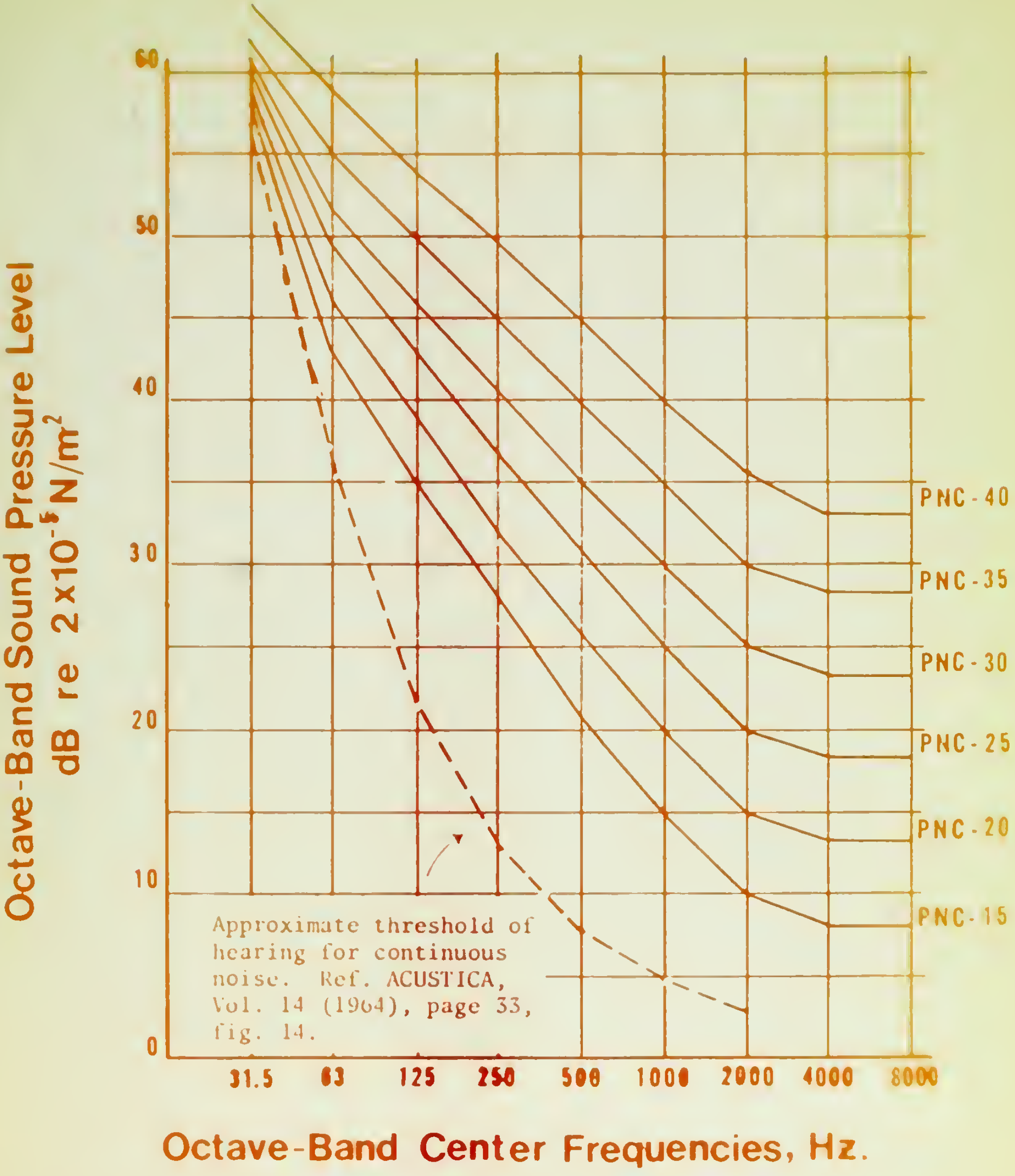
DAVID H. GAMBREL

PRESENT TITLE:	Corporate Mine Planner (Also serves as Corporate Staff Consultant in Acoustical Engineering)
EDUCATION:	Master of Science in Electrical Engineering, Seattle University, 1968. Bachelor of Science in Electrical Engineering, University of Evansville, 1960. Other post-graduate work taken at the University of Washington (Seattle), University of Missouri, and Washington University (St. Louis). Also took course in Underwater Acoustics at U.C.L.A.
PREVIOUS EXPERIENCE IN ACOUSTICS:	5 years - Senior development engineer and program manager at Honeywell Marine Systems Center in Seattle doing data analysis, system design, and test reporting on various sonar systems, underwater acoustic transducers, and underwater acoustic tracking systems. Also headed team of engineers analyzing noise problems in ships, and the effects of noise on acoustic homing systems.
PRESENT PROFESSIONAL MEMBERSHIPS:	1. IEEE (Institute of Electrical and Electronic Engineers) 2. IEEE (Professional Group on Sonics and Ultrasonics) 3. Missouri Society of Professional Engineers
OTHER PROFESSIONAL ASSOCIATIONS:	Has recently been nominated as a three-year member of the Board of Directors of the Midwest Noise Council. Has been Chairman of the Public Relations Committee for the Midwest Noise Council since its inception in 1972.

THOMAS G. HEALY

PRESENT TITLE:	Environmental Engineer
EDUCATION:	U.S. Maritime Academy, Paris Institute of Engineering, Bachelor of Science Degree in Industrial Engineering.
EXPERIENCE:	National Coal Association - Air Pollution Control Department for 13 years; Peabody Coal Company - 4 years
PRESENT PROFESSIONAL MEMBERSHIPS:	APCA (Air Pollution Control Association)
OTHER PROFESSIONAL ASSOCIATIONS:	Chairman-Technical Advisory Committee Midwest Coal Producers' Institute Board of Directors - St. Louis Chapter - APCA Board of Directors - Industrial Waster Control Council St. Louis Chairman - Ohio Coal Industry Clean Air Council Board of Directors - Midwest Noise Council

CHAMPION CLASP NO. 87
8¾ x 11½



Approximate threshold of hearing for continuous noise. Ref. ACUSTICA, Vol. 14 (1964), page 33, fig. 14.

FIGURE 10

PREFERRED NOISE CRITERIA-PNC-CURVES

1. Place this overlay on any of the figures showing noise level measurements to obtain a comparison with PNC curves. Make sure that levels overlay identical levels.

2. Refer to Table 1 to obtain recommended noise levels for various indoor functional activity areas, then compare this with measurements.

Ref. NOISE AND VIBRATION CONTROL, Leo L. Beranek, page 564, Fig. 18.3, McGraw-Hill, 1971.

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Peabody Coal Company
Environmental impact report, Peabody
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